2nd copy

MARINE PRODUCTS IN JAPAN

—Size, Technology and Research—

By

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FOREWORD

It would be difficult to think of a person better qualified to write on "Marine Products in Japan" than Dr. Eiichi Tanikawa. He has spent a fruitful professional career in the increasingly important field of marine food technology. As a matter of fact he may well be considered one of the pioneers. Dr. Tanikawa has taught and trained literally hundreds of students in marine food science at Hokkaido University, Hakodate, Japan, many of whom in turn are serving well in industry and as educators. As a scientist he has had a very productive career as a research worker as attested to by his international reputation and many scientific publications and contributions. In addition, he has worked closely with the Japanese fisheries industries in the solution of technical problems concerned with processing, product improvement and quality control.

It is a very fitting tribute to Dr. Tanikawa that upon his retirement his students are going to publish his book "Marine Products in Japan", an excellent summary of his work and contributions. Through this book the content of many fine research papers, originally published in Japanese, will be made more readily available to marine food technologists and students throughout the world. This is particularly important because of the increasing importance of marine food technology in helping in the solution of world food problems and in feeding a hungry world.

During 1960 and 1961 the writer, as a visiting professor at Hokkaido University, had the pleasure and stimulation of being associated with Dr. Tanikawa in work on an expanding food technology in Japan. In 1962～1963 Dr. Tanikawa spent some time as a visiting scientist in the Department of Food Science and Technology at the University of Massachusetts. At that time the writer had the privilege of reviewing his manuscript for "Marine Products in Japan".

William B. Esselen, Ph. D.
Commonwealth Head of Department
Department of Food Science and Technology
University of Massachusetts
Amherst, Massachusetts, U.S.A.

August 28, 1970

PREFACE TO THE RENEWED EDITION

It already passed five years since this book had been published with mimeograph. Few copy is available, however, as the food technologists over the world requested to obtain the publication.

I am retiring 31 st March, 1971, after 32 years at the Hokkaido University, 4 years of which I have been the Dean of the Faculty of Fisheries. A memento my students plan on my retirement is to publish my book "Marine Products in Japan". Accepting the plan they proposed lead to make revision on the first book, and to publish it with typography.

In the present renewed edition, recent papers of investigation are summarized on technical problems in processing and storing of marine products in Japan. I hope that the renewed edition would contribute the world wide progress of marine food technology.

I wish to acknowledge my sincere thanks to Dr. Terushige Motohiro, one of my students at the Faculty of Fishereies, Hokkaido University, who joined me in revising the manuscript. Thanks are due to many of my students and freinds at Universities, Research laboratories, and Industries in Japan, who helped me in publishing this book.

March, 1971

Eiichi Tanikawa

PREFACE

During 1960 and 1961 Dr. William B. Esselen, head of the Department of Food Science and Technology at the University of Massachussetts, U.S.A., was at Hokkaido University in Japan as a visiting professor in the current exchange program between the two universities. He worked on the development of an expanded food technology in Japan and we worked in close connection on that project.

At that time I discussed with him the size and status of the fishery industry and fishery processed products in Japan. Subsequently I thought that it might be worth while to make the subject of a paper in English, which I have done herewith.

In 1962, at Dr. Esselen's kind invitation I had an opportunity to visit the United States. During my stay at Amherst Dr. Esselen very kindly reviewed the manuscript. I have called it "Marine Products in Japan", and hoped to publish it as a book, thinking that there are probably many people who would like know the details of Japanese fisheries and marine products.

Dr. Esselen, Dr. Emil M. Mrak, chancellor of the Univeristy of California at Davis, and Dr. George F. Stewart, Chairman of the departtment of Food Science and Technology of the same University, recommended the manuscript to several publishers in the U.S.A. and U.K., in the thought such a book would provide important information knowledge on fish as a cheap protein resource in Japan. However, no publisher was sufficiently interested, possibly because several books concerning fisheries were already available.

Hence, I resolved to publish the manuscript by mimeograph with financial help from the Research Association for Technical Improvement of Canned Foods ("Kanzume-Gijutsu-Kenkyukai") at Tokyo. By this mean "Marine Products in Japan" has become available.

This book includes the technology of marine products utilization and the special problems in Japan which is the largest fishing country in the world, and has many types of processed products. This information can thus become available to food technologists and other students among English speaking people. If this book will stimulate interest in the processing of marine products in the world, it will be sufficient reward to me for my efforts.

I would like to express my gratitude to Dr. Esselen, Dr. Mrak and Dr. Stewart for their assistance and guidance. Without their kindness, this book might never have been completed.

March, 1965

Eiichi Tanikawa, Dr. Agr., D. Sc.
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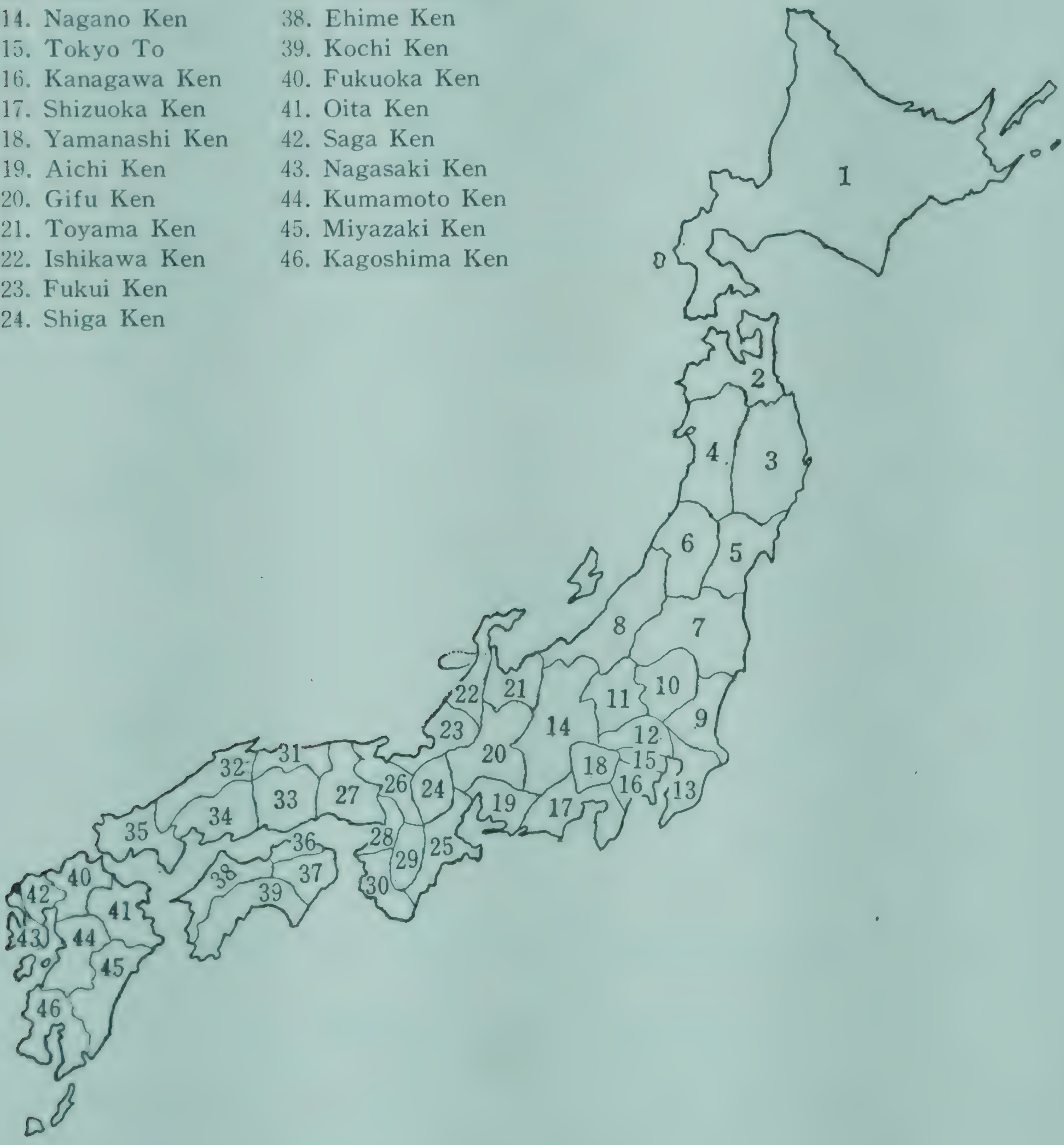
Ken = Prefecture

1. Hokkaido
2. Aomori Ken
3. Iwate Ken
4. Akita Ken
5. Miyagi Ken
6. Yamagata Ken
7. Fukushima Ken
8. Niigata Ken
9. Ibaragi Ken
10. Tochigi Ken
11. Gunma Ken
12. Saitama Ken
13. Chiba Ken
14. Nagano Ken
15. Tokyo To
16. Kanagawa Ken
17. Shizuoka Ken
18. Yamanashi Ken
19. Aichi Ken
20. Gifu Ken
21. Toyama Ken
22. Ishikawa Ken
23. Fukui Ken
24. Shiga Ken
25. Mie Ken
26. Kyoto Fu
27. Hyogo Ken
28. Osaka Fu
29. Nara Ken
30. Wakayama Ken
31. Tottori Ken
32. Shimane Ken
33. Okayama Ken
34. Hiroshima Ken
35. Yamaguchi Ken
36. Kagawa Ken
37. Tokushima Ken
38. Ehime Ken
39. Kochi Ken
40. Fukuoka Ken
41. Oita Ken
42. Saga Ken
43. Nagasaki Ken
44. Kumamoto Ken
45. Miyazaki Ken
46. Kagoshima Ken



OUTLINE OF JAPANESE FISHERY

I. Size of Industry

The waters surrounding Japan are continuous to the Pacific Ocean and o the Bering, Okhotsk, Japan, Yellow, and China Seas. Both warm and old sea currents stream into those waters. Therefore the catches of fish, hellfish and seaweeds are of both warm and cold sea types.

The total catch of fish and shellfish in Japan prior to World War II eached about 4 million metric tons, and other materials (e.g. seaweeds nd marine animals) approximated 0.5 million tons. The amount of the atch decreased towards the end of the War and reached a low point of million tons in 1945.

By 1952 the production had increased to pre-war levels and has increased o some extent since that time. According to the Annual Report of Catch tatistics of Fishery and Agriculture by the Ministry of Agriculture and orestry of the Japanese Government, the annual catch of marine products rom 1935 to 1968 is shown as Table 1-1.

The total catch in 1968 was 8,670 thousand tons (not including whale), hich is the maximum in the past. The itemized amounts do not include atches in fisheries outside the area of Japanese Main Land and pelagic sheries on high seas.

Table 1-1. Annual catch of marine products in Japan for years 1935-1968 (1,000 tons) (not including whale)

Year	Total amount	Fish	Shellfish	Other marine animals	Seaweeds
1935	3,977	3,361	254	196	514
1940	3,526	2,433	288	255	621
1943	3,734	2,251	690	302	491
1945	2,035	1,234	405	170	226
1947	2,206	1,470	215	360	161
1950	3,086	2,235	135	571	145
1953	4,524	3,291	317	611	304
1955	4,912	3,599	333	645	335
1958	5,506	4,017	458	627	340
1960	6,192	4,463	504	777	387

Year	Total amount	Fish	Shellfish	Other marine animals	Seaweeds
1962	6, 864	4, 900	270	860	350
1963	6, 698	4, 653	572	938	425
1964	6, 351	4, 745	528	596	361
1965	6, 908	5, 093	504	755	406
1966	7, 103	5, 232	547	745	436
1967	7, 851	5, 743	530	904	534
1968	8, 670	6, 340	553	1, 119	503

The annual catch by type of fishery for the year 1913-1968 is shown in Table 1-2.

Annual catch by principal fish species from 1964 to 1968 is shown in Table 1-3.

Table 1-2. Annual variation of the catch by type of fishery
(Unit : 1,000 tons)

Year	Grand total	Fisheries outside the area of Japanese main land	Pelagic fisheries on high seas	Domestic marine fisheries	Cultures in shallow sea	Inland water fisheries	Cultures in inland waters	Whaling (number)
1913	1, 649	68	—	1, 554	23	—	3	1, 586
1921	2, 206	172	—	2, 261	42	—	5	1, 279
1926	3, 071	116	14	2, 664	39	—	8	1, 588
1930	3, 186	218	46	2, 871	37	—	13	1, 717
1935	3, 977	200	49	3, 968	90	—	20	2, 453
1940	3, 526	94	42	3, 291	78	—	19	9, 628
1943	3, 356	102	—	3, 134	87	—	31	1, 491
1945	1, 824	—	—	1, 750	61	—	12	531
1947	2, 285	—	—	2, 257	23	—	4	3, 157
1950	3, 374	—	6	3, 249	48	63	5	5, 332
1953	4, 599	—	39	4, 348	144	57	8	6, 631
1955	4, 908	—	185	4, 473	154	82	11	11, 866
1958	5, 506	—	246	4, 951	214	78	15	19, 922
1961	6, 711	—	887	5, 400	322	81	18	20, 845
1962	6, 864	—	813	5, 583	362	84	20	22, 237
1963	6, 698	—	873	6, 200	389	85	23	22, 370
1964	6, 350	—	997	5, 868	362	89	30	24, 409
1965	6, 908	—	1, 115	6, 382	380	113	33	29, 986
1966	7, 103	—	1, 302	6, 558	405	103	36	22, 784
1967	7, 851	—	1, 863	7, 241	470	97	42	21, 088
1968	8, 670	—	2, 326	7, 993	522	103	52	21, 586

As seen in Table 1-3, the catch of cods including Alaska pollock was 2,472 thousand tons in 1968 which was the highest of the average annual catch. This is due to the increase of the catch in the Northern Pacific Ocean.

Table 1-3. Annual catch by principal fish species
(Unit : 1,000 tons)

Kinds of catch	1964	1965	1966	1967	1968
Total amount	6, 350	6, 907	7, 102	7, 850	8, 670
Total of fishes	5, 341	5, 849	5, 977	6, 646	7, 457
Tunas	427	430	398	367	352
Marlins	86	90	81	73	70
Bonito	166	136	229	181	168
Salmon	117	145	126	148	113
Mackerel, Pompanos ("aji") etc.	1, 512	1, 895	1, 803	1, 848	2, 241
Alaska pollack, Cod, etc.	1, 618	1, 544	1, 710	2, 199	2, 472
Sea breams, Shrimp, Crab, etc.	296	278	288	315	378
Others	1, 116	1, 328	1, 338	1, 510	1,659
Total of shellfish	527	503	546	529	552
Hard clams	16	13	10	6	6
Short necked clams	110	121	157	121	120
Scallop	6	5	7	6	5
Oyster	240	210	221	232	267
Others	155	154	151	164	154
Total of seaweeds	360	405	436	533	503
Laminaria ("Konbu")	142	126	155	175	169
Undaria ("Wakame")	48	74	79	121	124
Others	170	205	202	237	210

The catch of Mackerel ("Saba", *Scomber japonicus*) was 1,020 thousand tons in 1968. This amounted to an increase over the preceding year. The catch of common squid ("Surumeika", *Todarodes pacificus=Ommastrephes sloani pacificus*) was 770 thousand tons in 1968. This amount was 30% increase comparing with that in 1967. The catch of sand lance ("Ikanago", *Ammodytes personatus*) was 149 thousand tons in 1968. This amount was the maximum within the past 5 years and was 4% increase from that in 1967.

On the other hand, the catch of Pompanos (or Horse mackerel) ("Aji", *Trachurus japonicus*), saury (Pike mackerel) ("Sanma", *Cololabis saira*), flounder ("Hirame", *Platichthys stellatus*), salmon ("Sake", *Oncorhynchus* sp.), and bonito ("Katsuo", *Sarda* sp.) decreased in 1968, and the decreased amounts of these fish were 70(15%), 80(36%), 30(13%), 30(23%) and 20(9%) thousand tons, respectively, in comparison with those of the previous year.

The take of Laminaria ("Konbu") was 169 thousand tons in 1968, and this amount was 6 thousand tons less than that in the previous year. Laminaria are produced in the Soya, Hidaka and Oshima districts of Hokkaido.

The pelagic fisheries on the high sea include salmon fishing by mother ships, crab fishing by mother ships, trawler, cod longline fishing in the Northern Pacific Ocean, other trawler fishing in the South China Sea, and tuna longline fishing in the Pacific and Atlantic Oceans, etc.

The catches of the pelagic fishery on high seas for the years 1960~1968 are shown in Table 1-4.

Table 1-4. Catches in pelagic fishery on high seas

(thousand tons)

Year Types of fishery		1960	1961	1962	1963	1964	1965	1966	1967	1968
Northern Pacific Ocean	Mother ship salmon fishery	54	53	44	46	44	45	39	42	37
	Mother ship crab fishery	19	21	25	27	28	24	24	23	59
	Other trawler	471	639	534	338	438	403	453	778	843
South China Sea trawler		5	1	—	—	—	—	—	—	—
Large type trawler		12	57	94	162	228	361	489	723	1096
Tuna longline fishery	Mother ship	24	33	64	75	82	71	54	41	51
	Fishery at base port	234	300	324	314	265	252	267	265	247
	Fishing in Atlantic Ocean	72	82	60	59	69	86	49	23	21
	Fishery at foreign port	16	17	25	28	34	31	32	23	20
Large trawler at west of 130°E		367	374	330	344	302	324	333	338	325
Small trawler		213	215	208	208	230	252	268	276	258
Angling of bonito by small fishing boat more than 20 tonnage		80	120	119	93	119	131	168	142	125
Tuna longline fishery by small fishing boat more than 20 tonnage		38	50	62	56	55	58	79	75	78

Respecting the catches of pelagic fisheries on the high seas, salmon fishing in the northern Pacific Ocean ("Hokuyo", including North Pacific Ocean, Okhotsk and Bering Seas) was restricted in 1968 to 105 thousand tons including 49,750 tons in A area and 55,250 tons in B area by the Russo-Japanese Fisheries Treaty. The catch by large trawlers west of 130°E was 325 thousand tons in 1968. The annual catch is almost same from 1965 to 1968. It is noticeable that the catch of pelagic trawl fishery increased remarkably year by year from 1960～1968. Besides the fisheries above described, whaling is undertaken in both the northern Pacific Ocean and coastal fisheries besides Antarctic Ocean. The annual catch of whales for 1958～1968 is shown in Table1-2 During these years the number of whales caught in the Ogasawara Islands is unknown. A total of 21,586 whales were caught in 1968. The catch were apportioned to 39% of Antarctic Ocean, 35% of the north Pacific Ocean, and 26% of coastal whalings. As seen in Table1-2, the catch tends to decrease year by year from 1965 to 1968. A total of 21,586 whales were caught in 1968.

In Japan culture in shallow seas is also very important. Annual yields of products cultured in shallow seas for the years 1964-1968 are shown in Table 1-5.

The yield of cultured pearls was 104,186 kg from April 1967 to March 1968. The yield of cultured oysters (without oyster shell) was about 41 thousand tons in 1968. This amount was the highest for the past 5 years.

The yield of dried "Nori" which is a special product of Japan, was 2,955 million sheets in 1968. The yield tends to decrease gradually from 1964 to 1968. The reason of it depends on the decrease of the field of "Nori" culture and sea water pollution due to recent rapid development of industries and expansion of the fishery town.

In spite of decrease of "Nori" culture, the yield of cultured "Wakame" increased from 1966 to 1968. The yield of the cultured "Wakame" was about 70 thousand tons in 1968.

The catch of inland water fisheries was 103,212 tons in 1968. The yield of cultured fish was increasing tremendously year by year from 1964 to 1968. Most of the yield was cultured yellow tail, and a little was "Kuruma" prawns.

The catch by river and lake in inland water fisheries from 1963 to 1968 is shown in Table 1-6.

Total yield from culture of fish and other fishings in inland waters in 1968 was 52 thousand tons. The total yields by species are shown in Table

1-7.

The yield of cultured fish is increasing year by year. As above described, the catches vary from year to year. Moreover, within one year, the catches vary from month to month. The catches are large in spring and in autumn, but small in summer and in winter. The poor catches in summer or winter are called "Summer slack" or "Winter" slack, respectively. There are many fish which have their spawning season in the spring. Therefore the fish gather in particular places. In

Table 1-5. Yields of cultures in shallow seas

			1964	1965	1966	1967	1968
Pearl culture	Total yield (kg)		88,695	114,062	130,296	126,412	104,186
	Large balls (kg) (8.0 mm and over)		17,336	19,090	24,670	24,224	17,575
	Medium balls (kg) (6.0-8.0 mm)		38,355	46,815	65,120	63,136	51,332
	Small balls (kg) (less than 6.0 mm)		33,003	48,156	40,506	39,053	35,279
Oyster culture (without shell) (tons)			33,506	34,463	35,361	38,037	40,928
"Nori" culture	"Nori" dried in square sheet (million sheets)	Total number of sheet	4,439	3,190	3,958	3,551	2,955
		"Kuronori"	3,719	2,604	3,123	2,792	2,467
		"Mazenori"	530	389	624	610	340
		"Aonori"	190	195	210	148	146
	"Baranori" (tons) dried as it is		711	828	847	1,016	926
Fish culture (tons)			10,498	19,117	20,588	27,737	31,719
Yellow tail culture (tons)			9,493	18,083	19,269	26,712	30,774
"Wakame" culture (tons)			—	17,733	46,576	66,893	69,675

Table 1-6. Catches in inland water fisheries (1,000 tons)

		1963	1964	1965	1966	1967	1968
Total amount caught	Total amount	84	89	113	103	97	103
	Fish	48	50	53	49	50	52
	Shellfish	32	35	56	50	31	44
	Other aquatic animals	2	3	3	3	4	6
	Aquatic plants	0.5	0.3	0.3	0.3	0.2	0.7

		1963	1964	1965	1966	1967	1968
River	Total amount	43	48	65	58	53	60
	Fish	25	28	30	28	30	31
	Shellfish	16	19	34	28	22	27
	Other aquatic animals	0.7	0.5	0.5	0.5	0.6	0.6
	Aquatic plants	0.3	0.1	0.1	0.1	0.1	0.6
Lake	Total amount	41	40	47	45	43	42
	Fish	22	22	23	20	20	20
	Shellfish	17	15	21	21	19	16
	Other aquatic animals	2	2	2	2.7	3	3
	Aquatic plants	0.1	0.2	0.2	0.2	0.1	0.1

spring and autumn, plankton are grow abundantly at the junction of the warm and cold sea currents, and there is a very active migration of fish to these locations. The commerical fishing grounds move with the migration of fish.

Table 1-7. Yield of fishes by culture in inland water (tons)

Year	1963	1964	1965	1966	1967	1968
Total amount	23,371	29,780	23,096	36,375	41,852	51,932
Carp (including crucian carp)	8,125	90,90	9,474	11,268	12,508	16,075
Eel	9,918	13,418	16,017	17,015	19,605	23,640
Trout	3,927	5,412	5,745	6,231	7,882	9,454
"Ayu"	537	994	—	—	—	—
Mullet	515	566	—	—	—	—
Other fish	249	215	—	—	—	—
Snapping turtle	28	29	—	—	—	—
Frog	1	0	—	—	—	—
Other	59	51	1,858	1,858	1,856	—

II. Processed Fish Products

1. Processed products

Marine products are perishable, so the catch must be processed except for that portion which is sold for eating in fresh condition. The production of processed products in 1936 was at a maximum, and that in 1945 (the end of the War) was the minimum. Since then production increased gradually until it recovered to the pre-war level in 1951-1952.

In 1968, the total amount of processed products is in excess of 4,994 thousand tons.

If the ratio of the yield of the processed products to raw marine material is 50%, the amount of raw material to be used must be above 9,000 thousand tons.

If the ratio is 65%, the amount of the raw material to be used is 7,500 thousand tons. That is to say, the greater part of the raw material is probably processed.

In Japan, raw marine materials are processed into frozen, dried, smoked, salted, and canned foods, and into fish paste ("Kamaboko", fish sausage, ham, etc.), seasoned foods("Tsukudani", etc.) and dried fish stick ("Fushi") etc.

The amounts of production of the processed fish foods for 1964-1968 are shown in Table 1-8.

The amount of the production of the processed marine products by kinds varies according to the amount of the respective catches. The amounts of dried, boiled and dried, salted products are also the same as those before the war.

The amounts of frozen products, fish paste (e.g. fish sausage) and seasoned products ("Tsukudani") have increased since the War. This may be due to the change of the peoples mode of living. For example, one likes the dressed fish more than round fish, so that frozen fish fillets or fish sticks are very popular. The ready-to-eat-foods (e.g. "Kamaboko", fish sausage, "Tsukudani") are sold abundantly. Therefore the amount of production of those processed foods has increased recently.

On the contrary, the production of fish oil decreased. Before the war, 70% of the catch was used to manufacture fish oil and fish fertilizer. At the present time, only 15% of the catch is manufactured into fish oil. Thus whale oil occupies the top place in the production of fish oil. The production of fish meal and solubles for livestock feeding is increasing in importance.

2. **Production of canned fish**

Production of canned fish which decreased immediately after the war has increased recently. The amount in 1965-1968 is shown in Table 1-9.

Table 1-8. The production of processed marine products in Japan (1,000 tons)

	1964	1965	1966	1967	1968
Grand total amount	3,381	3,927	4,055	4,384	4,994
Processed in land factories					
Total amount	2,562	3,057	3,288	3,509	4,071
Dried products	36	40	38	45	48
Salted and dried products	106	122	121	125	138
Boiled and dried products	99	100	82	88	101
Smoked products	9	8	6	8	12
Salted products	117	141	156	148	177
Dried fish stick ("Fushi")	84	79	83	81	89
Fish paste products	734	797	895	911	999
Frozen products	766	1,140	1,217	1,340	1,632
Seaweeds products	55	57	62	76	67
Others	147	153	195	231	227
Oil	27	40	42	46	56
Fertilizer (including fish meal)	375	373	387	404	524
Processed on floating factories (whale, salmon, tuna)					
Total amount	818	869	766	875	923
Salted products	12	12	10	8	6
Frozen products	586	658	608	681	723
Others	7	5	1	—	—
Oil	153	134	82	77	78
Fertilizer (including fish meal)	58	58	63	107	115

Table 1-9. Production of canned fish in 1965-1968 (converted number of cases of 48 one pound cans)

	1965	1966	1967	1968
Crab	285,244	318,311	369,214	362,444
Salmon	1,728,301	1,490,520	1,708,792	814,449
Tuna	2,409,735	1,943,650	3,263,823	2,634,177
Mackerel	2,903,790	3,792,813	4,999,218	7,663,256
Sardine	182,526	250,963	168,515	54,366
Saury	1,049,749	578,344	501,264	507,792
Pompanos ("Aji")	682,228	820,667	462,201	232,766
Whale meat	1,192,648	949,907	986,227	760,551
Squid	417,768	193,656	452,914	306,503
Other fish	417,652	355,684	315,339	217,977
Shellfish	655,536	842,273	1,022,250	915,299
Other processed food	247,932	218,608	220,152	236,154
Other marine foods	—	—	—	—
Total amount	12,173,109	12,755,396	14,469,914	14,705,781

The total amount of marine canned foods produced in 1968 was 14,705 thousand cases (converted number of cases containing 48 one pound cans), of which the amount of marine canned foods made from the principal catches was 14,251 thousand cases. The difference (about 454 thousand cases) was made from the marine products other than the principal catches.

III. Exports of Marine Processed Products

1. Total Exports of Marine Processed Products

Among marine processed products, almost all of the canned foods, and frozen products are exported, but the amounts of salted, dried, smoked foods are of less importance. The amounts of liver and whale meat oils are decreasing for export. They are consumed in domestically. The amount of exports of marine processed products is presented in Table 1-10.

Table 1-10. Exports of marine processed products

Year	Frozen products (tons)	Canned products (1,000 cases)	Salted dried products (tons)	Oils (tons)	Pearls (kg)
1964	324,860	11,929	4,809	107,796	88,709
1965	288,012	10,801	6,950	97,305	93,951
1966	269,751	13,535	5,344	55,678	104,459
1967	219,435	14,822	5,036	55,657	93,466
1968	222,902	18,166	8,486	27,132	88,260

2. Exports of Canned fish

Almost the entire pack of canned marine foods is exported. The amount of the important kinds of canned marine foods exported in 1968 are shown in Table 1-11.

IV. Utilization of the Most Important Fish in Japan

1. Salmon

There are six kinds of salmon (*Oncorhynchus*) found in Japanese and Aleutian waters. Red salmon (*O. nerka*), pink salmon (*O. gorbuscha*), silver salmon (*O. kisutch*), chum salmon (*O. keta*), king salmon (*O. tschawytscha*) and "Masu" (*O. masou*).

Among these species, red salmon is the most valuable as the raw material for canning. It is also used as the raw material of smoked salmon. Silver

Table 1-11. Exports of principal canned fish from Japan in 1968

Destination	Tunas	Salmon	Sardine	Saury	Pompanos and Mackerel	Crab	Others
Ryukyu	918	9	—	74	1,721	6	593
Korea	—	—	—	—	—	—	0
Hong Kong	13	3	3	1	210	—	338
South Vietnum	—	—	—	51	14,484	—	18
Maraya	—	1	3	179	2,954	1	179
Singapore	5	5	15	47	5,015	13	469
Philippine	121	1	514	81	56,979	1	1,462
India	3	1	—	—	—	0	—
Lebanon	593	1	—	—	92	1	1
Sweden	248	43	—	—	19	356	14
U.K.	3,252	27,317	—	—	322	690	2,247
Netherlands	1,965	1,387	3	6	678	193	14
Belgium	1,857	772	17	144	564	227	3
France	18	1,441	4	—	296	1,079	59
Germany	13,245	35	—	67	578	95	57
Switzerland	2,106	22	—	—	9	1	9
Spain	—	4	—	—	—	41	779
Italy	291	68	—	9	62	15	494
U.S.S.R.	—	—	—	—	—	—	—
Greece	79	19	3	97	1,302	10	11
Canada	2,538	1	—	—	25	43	2,010
U.S.A.	27,297	538	—	28	7,129	1,797	5,648
Puerto Rico	—	—	—	—	—	—	—
Liberia	13	3	—	—	44	—	—
Australia	74	3,563	—	2	273	170	423
New Guinea	—	2	—	109	5,407	0	1
Canary Isls.	—	7	—	—	—	9	—
Fiji Isls.	0	0	0	—	1,383	2	2
Samoa Isls.	—	—	—	—	190	—	1

Salmon is next in quality to red salmon as the raw material for the canned product. It is used mostly as raw material for canning. Chum salmon is also canning, for light-salted salmon ("Aramaki sake") and heavy-salted salmon ("Shiobiki") and for frozen salmon. Pink salmon is used as raw material for canning or for heavy salted salmon ("Shiobiki sake"). The quality of canned chum salmon and pink salmon is inferior to that of canned red salmon. Therefore the former are sold mainly on the domestic market. "Masu" (*O. masou*) is used mainly for fresh fish, but is used also as the raw material for canning. Canned "Masu" is slightly inferior in quality to canned pink salmon, because its flesh is softer than that of the latter. Canned "Masu" is also sold domestically. King salmon is used for canning.

2. Tuna and bonito

Tuna and bonito are found living in warm ocean currents. They are both large fish. To tuna and similar fish, belong the albacore ("Bincho maguro", long fin tuna, *Germo germo*), the tunny ("Hon-maguro" *Thunnus orientalis*), the blue fin tuna ("Kuro-maguro", *Thunnus saliens*), the yellow fin tuna ("Kihada-maguro", *Germo macropterus*), the barred marlin ("Mekajiki", *Xithias gladius*), the striped tuna ("Katsuo", *Gymnosardae epelamis*), the bonito ("Kitsune-gatsuo", *Sarda chilensis*) and the yellow-tail ("Buri", *Seriola dorsalis*).

When processed, the color of the meat of albacore is white, therefore the canned albacore is called white meat tuna. The canned meat of other fish of this group is light brown in color, so it is called light meat tuna.

Among tuna and similar fish, tunny meat is preferably eaten as raw flesh ("Sashimi" and "Sushi"), albacore is almost entirely used for canned tuna in this country. The meat of canned albacore is resembles chicken meat, therefore it is sometimes called "Sea chicken". Blue fin tuna, yellow fin tuna, barred marlin, yellow tail, striped tuna and bonito are also used as raw material for canning. The kinds of canned tuna include that processed in oil, or in brine and as the seasoned meat. Canned tuna in oil or in brine is almost all exported. Seasoned tuna is made from the flake meat, and it is consumed in the domestic market.

Bonito is used as raw material for "Katsuo-bushi" which is a special dried fish product unique to Japan. "Katsuo-bushi" is used for preparing soup. Yellow-tail is consumed as fresh fish either boiled or broiled. Tuna including albacore, blue fin tuna, yellow fin tuna and barred marlin are also frozen and exported to the United States.

Recently a species of barred marlin has been used as the raw material for fish sausage.

3. Mackerel

There are two kinds of mackerel (*Scomber*) which are caught in Japanese waters. One of them is "Masaba" (*Scomber japonicus*) and the other is

"Gomasaba" (*Scomber japeinocephalus*).

Scomber japonicus is caught widely around the Japanese islands. The fish which is caught in northern Japan is fatty and tasty. *Scomber japeinocephalus* lives with *Scomber japonicus*, but the former do not live in northern Japan. The meat of the former is inferior to *Scomber japonicus* in taste. *Scomber japeinocephalus* is consumed as fresh fish. *Scomber japonicus* is used as a raw material for canning. The fish migrates according to the optimum temperature of the sea water. Therefore, the catch varies owing to changes of the water temperature during the year. Mackerel is processed for sale as canned boiled mackerel or as seasoned mackerel. Canned seasoned mackerel is consumed domestically.

4. **Sardine**

In the families of *Clupeidae* and *Engraulidae* caught in waters surrounding Japan, there are six genera in the former and two in the latter. In the former group include *Clupea pallasi* ("Nishin"), *Sardinia melanosticta* ("Maiwashi), *Etrumeus micropus* ("Urume-iwashi"), *Stolephorus japonicus* ("Kibinago"), *Sardinella zunasi* ("Sappa") and *Illisha elongata* ("Hira"), and to the latter group belong *Engraulis japonicus* ("Seguro") and *Anchovia inducus* ("Anchovy").

Among these genera, *Sardinia* is used as the raw material of so-called canned sardine. *Sardinia melanostica* is caught in the waters about Japan throughout the year. According to the locality of the catch or catching period, there is a variation in its value as a raw material for canning. According to the length of its body, the sardine is classified into small ("Koba") (below 14cm), middle ("Chuba") (14-16cm) and large ("Oba") (above 16cm). Sardine caught in the Pacific Ocean side of Chiba Prefecture are of middle size, and on the Tokyo Bay side of the same prefecture are of large size. The fish caught off Nagasaki Prefecture are also large in size. The fish caught in Hokkaido waters is middle size. As raw material for the canned sardine, the fish which are of large size and fatty are good.

In addition to its use for canning, *Clupeidae* is eaten fresh, dried or salted. Because the catch is very large, not all of it can be eaten fresh. In former days much of the catch of this fish was manufactured into fertilizer. Since 1945 the amount of the catch has decreased. The small sized of *Engraulis japonicus* is dried and used for preparing soup. The dried merchandise was in former days exported to China. Approximately half of the canned sardine pack is exported.

5. Saury (Pike mackerel)

Saury (Pike mackerel) ("Sanma", *Cololabis saira*) is occur abundantly in the seas surrounding Japan, particularly in the northern Pacific Ocean. Their main groups are found in great numbers in the northern Pacific Ocean in July and August. They live in both cold and warm ocean currents at an undersea temperature of 17°C. In autumn, as these cold and warm currents begin to flow southward, the fish likewise migrate southward with the currents, reaching the shores of central Japan Main Land in about December, and thereafter take to the ocean.

The catches are so great, that the availability of this fish for domestic use is quite high. Besides being extensively consumed in their fresh state, they are dried, canned, salted and otherwise made into seasoned food products and fish fertilizer. Both fresh and dried sauries are much liked by the consuming public throughout the country because of their excellent taste.

6. "Aji" (Pompanos, Jack mackerel)

"Aji" (Jack mackerel, *Trachurus japonicus*) is also one of the important fish in Japan. Recently the annual catch has grown to about 423 thousand tons. "Aji" is consumed mostly as fresh fish. The proportion of consumption as raw material for canning is only 4%. This fish is also consumed as salted or dried form.

7. Cod

Cod ("Tara", *Gadus macrocephalus*) was caught to the extent of 96 thousand tons in 1968. This is also one of the important fish in Japan. From ancient times cod has been manufactured into salted and dried fish. It is also used as raw material for canning. Because of its muscular properties, the canned boiled cod is not well liked. However, it is preferable to prepare canned smoked cod after it has been smoked.

8. Alaska pollack

Alaska pollack ("Sukeso-tara", *Theragra chalcogramma*) caught in waters surrounding Hokkaido resembles cod, but the size is smaller. The amount of the catch was 915 thousand tons in 1968. It lives in cold currents. As in the case of cod, Alaska pollack is not extensively processed into canned fish. Most of the roe and liver of this fish are profitably processed. The former is manufactured into salted roe ("Momijiko), and is consumed domestically. The latter is used as raw material for cod liver oil. The remainder of the carcasses is dried in cold weather. This is preferably eaten by Koreans as "Mintai". The fish have been filleted and dried under the name "Sukimi", or crushed and frozen as raw materials of fish sausage or Japanese style fish paste under the name "Surimi". A small part of the catch is processed for canning.

9. Atka mackerel

Atka mackerel ("Hokke", *Pleurogrammus azonus*) also lives in cold ocean currents; the catch is also abundant. The amount was 87 thousand tons in 1968. This fish has a characteristic odour, but the meat has a good taste. It is consumed in the fresh state, and when the catch is abundant, it is salted.

10. Whale

Whale is caught in the Antarctic Ocean or north Pacific Ocean by Japanese whalers. The kinds of whale caught are blue whale ("Shironagasu kujira", *Balaenoptera muscues*), fin whale ("Nagasu-kujira", *Balaenoptera physalus*), humpback whale ("Zato kujira", *Megaptera nodosa*), sperm whale ("Makko-kujira", *Physeter catodon*), grey whale ("Koku kujira", *Rhachianectes glaucus*), and sei whale ("Iwashi kujira", *Balaenoptera borealis*).

Among these whales, the meats of fin whale, blue whale and sei whale are used for fresh meat or salted meat. Recently the meat has been processed for canning in the seasoned state, especially abdomen meat which is taken at the boundary between the muscular part and the fat layer, and is rich in connective tissue. The amount of canned product was about three million cases in 1962. This canned meat is consumed domestically instead of canned beef. Whale meat is processed by bacon-style smoking, and is also used as one of the raw materials in making fish sausage.

11. Crabs

Largs sized crabs are used as raw material for canning. A small amount is used in the fresh state domestically. There are four important species; king crab ("Taraba-gani", *Paralithodes camtschatica*), horse-hair crab ("Kegani", *Erimacrus isenbeckii*), "Zuai gani" (*Chionectes phalanguim*) and "Hanasaki-gani" (*Paralithodes brevipes*). King crab and "Hanasaki-gani" are caught in northern Hokkaido waters to Kurile Islands waters and the

Okhotsk sea. Horse-hair crab is caught in northern Hokkaido waters. "Zuai-gani" is caught along the Japan Sea and off Korea. King crab meat is canned in largest amount ; it is the best in taste. "Zuai-gani" follows to the taste of king crab. Canned horse-hair crab meat is thin, and the taste is inferior to that of king crab meat. Canned crab is an important export from Japan.

12. Squid

Squid ("Ika", *Ommastrephes sloani pacificus=Todarodes pacificus*) became an important catch after the recent war. The amount of the catch was about 770 thousand tons in 1968.

From ancient times squid has been manufactured into dried squid ("Surume"), which was exported to China. It is also salted and fermented with the viscera enzyme (especially liver enzyme). This food is called "Shiokara" in Japan ; it is consumed (as a relish) with "Sake". Recently squid has been smoked for eating with beer under name "Chinmi-hin". About 4% of the raw material is used for the canning.

13. Shell-fish

The total amount of shell-fish taken is about 597 thousand tons in 1968. The catch is being increased by culture every year. Almost all the shellfish are consumed in daily dishes.

Among the shell-fish, the oyster ("kaki"), bloody shell ("Akagai", scallop ("Hotategai"), ear-shell ("Awabi") and baby clam ("Asari"), *Tapes phillippinarum*) are processed for canning.

Shell fish is utilized for manufacture into dried merchandise, especially scallop and ear-shell which were important exports to China.

14. Others

Besides the kinds of fish and shell-fish above described, there are many marine products in Japan, for example, such as octopus ("Tako"), sea bream ("Tai"), shrimp ("Ebi"), fresh water fish such as eel ("Unagi") and "Ayu", and seaweeds such as tangle ("Konbu", *Laminaria*), laver ("Nori") and "Wakame" (*Undraria pinnatifida*). Some of them are used as raw material for canning. But the amount of output is less than any of those described above.

Tangle is dried for export to China, or is consumed domestically. The dried tangle is used to prepare soup. Dried laver is also eaten preferably domestically.

Eel is used broiled as "Kabayaki". "Ayu" is eaten in the fresh state, and other fish are consumed also in the fresh state or salted or dried form.

V. Utilization Apportion of the Catches to Various Processed Products

The catches are utilized into various processed products increasing year by year in Japan. The utilization apportion of the fish and shellfish (including other marine animals, but not including seaweeds and pearl, etc.) is shown in Table 1-12.

Table 1-12. Utilization apportion of the fish and shellfish in Japan (1,000 tons)

Products	1964	1965	1966	1967	1968
Total amount of fish and shellfish caught	6,350 (100)	6,907 (100)	7,102 (100)	7,850 (100)	8,670 (100)
Raw material (including frozen product)	2,107 (33.0)	2,440 (35.2)	2,352 (33.1)	2,522 (31.0)	2,672 (30,8)
Canned products	455 (7.1)	449 (6.5)	517 (7.3)	607 (7.2)	614 (7.1)
Processed products					
Total amount	3,061 (48.1)	3,310 (48.1)	3,509 (49.5)	3,684 (47.1)	3,968 (45.8)
Fish paste	1,499 (23.6)	1,632 (23.4)	1,856 (26.2)	1,909 (24.3)	2,109 (24.3)
Dried product	167 (2.6)	183 (2.6)	166 (2.3)	189 (2.4)	203 (2.3)
Salted and dried	193 (3.0)	208 (2.9)	213 (3.0)	216 (2.7)	236 (2.7)
Boiled and dried	438 (6.9)	442 (6.4)	366 (5.1)	394 (5.0)	417 (4.8)
Smoked	25 (0.3)	24 (0.3)	18 (0.2)	25 (0.3)	26 (0.3)
Dried fish stick ("Fushi")	189 (2.9)	180 (2.6)	190 (2.6)	170 (2.1)	195 (2.3)
Salted	134 (2.1)	166 (2.4)	181 (2.5)	161 (2.0)	195 (2.3)
Others	109 (1.7)	129 (1.8)	152 (2.1)	161 (2.0)	143 (1.7)
Dried seaweeds	303 (4.8)	343 (4.9)	364 (4.9)	455 (5.7)	440 (5.1)
Oil and fertilizer (including fish meal)	668 (10.5)	643 (9.3)	651 (9.2)	958 (12.2)	1,351 (15.6)

Year by year the apportion of frozen products decreased and that of the raw material for the processed products has increased. The apportion to the processed products has increased to about 50%. It is interesting that fish paste products (e.g. fish sausage, fish ham and Japanese style fish paste) increased, and dried products decreased. The apportion to the canned foods also increased. In other words, the production of the processed products, especially new type of foods, increased year by year owing to the change of peoples mode of living. The rapid increase of oil and fertilizer is due to need of fish meal for feeding of poultry and cuttles.

MANUFACTURED MARINE PRODUCTS

I. Classification

In Japan manufactured marine products are usually classified roughly into articles of food, articles for industrial use, articles for agricultural use and articles for medical use.

Food products include dried, salted, canned and seasoned foods, plus frozen materials which are used in the same way as fresh raw material.

Articles for industrial use are fish oil, leather, fish glue, alginic acid, whale bone products, coral, shell (buttons), pearls and pearl essence, etc. Materials for agricultural use include dried fish scrap, fish meal, and fish soluble. Items for medical use are liver oil and insulin.

This classification is based on the main uses. For example, fish oil which is prepared for industrial use, may be used as an article of food after refining or processing. But in this case, fish oil is classified as an industrial material. Fish meal is similarly classified as an article for agricultural use, although it is also used as an article of food after further processing.

1. Food Products

1) Frozen food

Round fish, fish fillet, fish-steak, prepared frozen fish, fried fish sticks, etc. (many kinds of fish are used.)

2) Dried foods

a. Dried only

Dried squid (*Todarodes pacificus*)("Surume"), dried herring ("Migaki-nishin"), dried half-mouthed sardine(*Engraulis japonicus*) ("Ta-zukuri"), dried shark fin ("Fuka-bire"), dried young sardine ("Tatami-iwashi"), dried shrimp(*Pandalus platyceros*)("Hoshi-ebi"), dried flat fish ("Hoshi-garei"); dried laminaria ("Konbu"), dried seaweeds (Undaria) ("Hoshi-wakame"), and dried laver ("Hoshi-nori").

b. Boiled and dried

"Fushi" (boiled and completely dried fish meat)—"Katsuobushi" (bonito), "Saba-bushi" (mackerel), "Iwashi-bushi" (Sardine), boiled and dried sea-cucumber ("Kinko"), boiled and dried shrimp ("Ni-boshi-ebi"), dried abalone ("Hoshi-awabi"), etc.

c. Roasted and dried

Roasted and dried fish: Sea-bream (*Pagrosomus unicolor*), mackerel (*Scomber japonicus*), sardine (*Sardinops melanosticta*), etc.

d. Salted and dried

Salted and dried cod (round cod fish, split cod fish), round horse-mackerel ("Kusayano-himono"), sea-bream, mackerel, saury-pike ("Kamasu", *Sphyralna pinguis*), flying fish (*Cypselurus agoo*), sardine (*Sardinops melanosticta*), flat fish ("Hoshi-garei"), salted and dried mullet-roe, etc.

e. Smoked

Smoked fish (herring, salmon, etc.)

f. Frozen and dried

Stock fish (cod, Alaska pollack) or agar.

3) Salted

Mild dry-salted salmon ("Aramaki-sake"), heavy dry-salted salmon ("Shiobiki-sake"), salted herring, yellow tail (*Serola dorsalis*), mackerel (*Scomber japonicus*), sardine, saury, squid, salmon-roe, herring-roe, etc.

4) Seasoned products

A. Fermented Foods

a. Fermented foods ("Shiokara")

Bonito viscera ("Katsuo-no-shiokara"), squid meat ("Ika-no-shiokara"), sea urchin (*Halio crassispina* or *Stronly locentrotus pulcherrimus*), milt and roe ("Uni-no-shiokara"), sea-cucumber viscera (*Stichopus japonicus*) ("Konowata"), etc.

b. Cured-fermented foods

i) "I-sushi" (cured-fermented in boiled rice)

"Ayu-sushi", "salmon-sushi", "herring-sushi", "flat fish-sushi", etc.

ii) "Koji-zuke" (cured-fermented in "koji")

"Ayu-no-koji-zuke", mackerel in "koji", herring in "koji", etc.

iii) "Nuka-zuke" (cured-fermented in rice-bran)

Sardine in rice-bran, herring in rice-bran, globe fish in rice-bran, globe fish roe in rice-bran, etc.

iv) "Kasu-zuke" (cured and fermented in "sake"-lees)

Abalone meat in "sake"-lees, cod meat in "sake"-lees)

v) "Su-zuke" (pickled products)

Sardine in vinegar, mackerel in vinegar, pickled octopus and squid meat.

vi) Fermented fish sauce

"Shottsuru" (fermented sand fish sauce), "iwashi-shoyu" (fermented sardine sauce)

B. Fish paste

"Kamaboko", "Chikuwa", "Hanpen", fried fish meat ball ("Satsuma-age"), fish meat ham, fish sausage, etc.

C. Boiled and seasoned

"Tsukudani", "Shigureni", "Ameni", seasoned fish meat flour ("Denpu"), seasoned "fish and bean mash" ("Gyo-miso")

D. Seasoned and dried

"Seasoned and dried fish" ("Sakura-boshi"), fish-cracker ("Uo-senbei"), "dried and spread squid meat" ("Noshi-ika"), seasoned and smoked squid meat ("Ika-kunsei"), dried and seasoned laver ("Ajitsuke-nori"), dried and seasoned Undaria ("Ajitsuke-wakame")

5) Canned foods

a) Boiled

Salmon, crab, scallop, mackerel, saury, etc.

b) In oil

Tuna, sardine, saury, etc.

c) Seasoned

Seasoned fish with soy bean sauce (mackerel, sardine, horse-mackerel, saury, bonito, tuna flake meat, shell-fish, etc.

d) In tomato sauce

Sardine, saury, herring, etc.

2. Articles for Industrial Use

1) Fish and marine animal oil
   Fish (sardine, saury), whale, etc.
2) Leather and fur
   Leather (skins of shark, whale), fur (fur seal).
3) Fish glue
   Fish bone, scales, etc.
4) Alginic acid
5) Hand made goods
   Whale bone, coral, pearl, and shell

3. Agricultural Products

1) Fish scrap (cake)
   Saury, herring, sardine, etc.
2) Fish meal
   a. White meal (cod, flat fish, Alaska pollack)
   b. Brown meal (sardine, saury etc.)
3) Fish solubles

4. Medical Products

1) Liver oil
   Cod liver, Alaska pollack liver
2) Insulin
   Cod, whale, tuna, bonito etc.

II. Parts of Raw Materials Employed in Processed Products

As raw materials for processed marine products animals and plants, such as mammal, fish, amphibian, mollusc, crustacea and algae are used. Even in the same kind of fish, for example, the method of utilization of parts of the carcass may according to its size.

1. Whole fish body

Frozen fish (small fish), seasoned articles (small fish), fish meal, etc.

2. **Fish meat**

Edible grade fish flour made from fish after removal of head and viscera.

3. **Fish roe**

Salted fish roe, salted and fermented fish roe —— salted mullet roe, caviar, salted globe fish roe in rice-bran, salted and fermented sea urchin roe and milt, salted and fermented sea bream roe, etc.

4. **Fish stomach**

Salted and fermented bonito stomach, etc.

5. **Fish kidney**

Salted and fermented salmon kidney, etc.

6. **Fish liver**

Liver oil: Cod, Alaska pollack, fat bass ("Ishinagi", *Sterrolepis ishinagi*), tuna.

7. **Skin**

Leather — whale, shark, Moray eel ("Utsubo", *Gymnothorax Kidako*).

8. **Fins**

Dried fin (shark), boiled and dried fin (shark).

9. **Bone and teeth**

Cigarette holder, spoon (sperm whale).

10. **Scales**

Pearl essence, hair-tail (*Trichiurus haumela*), herring.

11. **Brown algae**

Foods ... Dried laminaria, dried and cut laminaria, seasoned laminaria, laminaria-cake; dried Undaria, dried Cystophyllum, alginic acid [Laminari, "Kajime" (*Ecklonia cava*) etc.], iodine (laminaria).

12. **Red algae**

Foods ... Dried laver ("Nori"), dried and seasoned laver.
Seaweed glue ... "Funori".
Anthelminthic ... "Kaininso" ("Makuri", *Digenea simplex*).
Agar ... *Gelidium amansii*, others.

13. **Green algae**

Foods ... Dried green algae, green algae seasoned with soy bean sauce.

14. **Blue-green algae** ("Ranso", *Cyanophyceae*)

Foods ... "Suizenji-nori".

III. Selection of Raw Materials for Preparing Commercial Products

For religious reasons the Japanese have preferably eaten fish from olden times. Fish is extensively used in the diet, especially in the care of the older people. With the increase of the catch, the Japanese have utilized fish recently for preserved foods, e.g. canned, refrigerated, dried, salted articles, etc.

In preparing preserved or other products, suitable treatment should be devised according to their nature (e.g. shape, size, chemical properties of the fish and the amount of the catch, fishing season, etc.). As above mentioned there are many kinds of marine products, but the method of utilization is not necessarily the same, because many processed articles are made according to the properties of the raw materials.

As to size of fish, large fish can be frozen or canned by filletting or cutting the fish body, but small fish are restricted in utilization. For example, fishes smaller than 3 cm in length are utilized only for "Tsukudani" (a kind of seasoned food), or "boiled and dried products." On the other hand, there are some products which must be, or are preferably manufactured from small fish, e.g. "gisuke-ni" (a kind of "seasoned and dried product") or "boiled and dried sardine." There are also some products which are preferably manufactured from small fish of some definite uniform size, e.g. "canned sardines in oil." On the contrary, there are some articles which are manufactured from fish of any size, shape or kind. For example, fish paste products (e.g. "Kamaboko", fish sausage or fish ham, etc.) can be manufactured from any size of fish.

The quality of raw materials is based on the properties of the meat, such as taste, texture, color and chemical components. The chemical and physical properties are particularly important. Many commercial articles are manufacturing by utilizing those properties. For example, bonito is used for making "dried bonito"; saury-pike ("Kamasu") is used to make dried articles; milt and roe of sea urchin are used to make salted and fermented articles; squid and cuttle fish are used for dried articles. Jack-mackerel ("Aji", *Trachunus japonicus*), mackerel scad ("Muroaji", *Decapterus muroadsi*) and flying fish (*Cypselurus agoo*) are used to make "salted and then dried articles", because their meat becomes elastic when salt is added. Alaska pollack and cod are denaturable and their muscle tissues are easily separated, hence they are used to make "Soboro" (a kind of seasoned fish flour).

"Guchi" (*Nibea mitsukurii*), true lizardfish ("Eso", *Saurida undosquamin*) and sharks, of which the meat becomes elastic when they are ground and heated, are used for making "Kamaboko" (fish paste) and fish sausage.

Processing may alter or change the flavor of raw fish meat. For example, frigate mackerel ("Meji", *Auxis tapeinosoma*) meat is better than skipjack meat (*Katsuwonus selamis*) in taste in the raw state, but the former is inferior to the latter when they are processed. Sea bream ("Tai", *Rhabdosargus sarba*) is of good taste when it is used as raw meat ("Sashimi"), but it deteriorates in flavor and loses its value, if it is used for making "Fushi" ("Steamed and dried article") or for canning.

Even when similar fish are used for making commercial products, the taste differs by the species. For example, tuna (*Thunnus thynnus*) has the best taste as raw meat ("Sashimi"), but it is not fit for canning, because during processing its color becomes dark; on the other hand, albacore (*Thunnus alaunga*) is very good for canning, and "Kurokawa-kajiki" (blue marlin, *Tetrapturus amplus*) is the best raw material for fish paste products (fish sausage and ham).

The method of utilization of fish meat may be different according to its color. For example, "Urume-iwashi" (round herring, *Etrumeus micropus*) is fit for making dried round fish, but it is unsatisfactory for making "canned sardine in oil," because the inferior color of this canned fish.

The chemical composition of the raw material may influence the manner in which it is utilized. For example, the fat content of fish meat is highest before the spawning and has a good taste, but if fish meat having a large amount of fat is used for making dried foods, the fat will be oxidized during preservation. The dried products should be made from raw fish of low fat content.

When fish is characterized being rich in some special chemical components, the component may be isolated. For example, Vitamin A is extracted from cod fish liver, a rich source of this vitamin. Similarly insulin is extracted from the pancreas (islets of Langerhans) of cod, skipjack, tuna and whale. Agar is made from seaweeds which have a large amount of jelly substance, such as *Gelidium*.

The characteristics of each raw material should be known so that they can be utilized with maximum effectiveness in the preparation of commercial by-products. In general the characteristics of marine products may vary according to the season when caught.

IV. Technical Problems in the Utilization of Marine Products in Japan

The Japanese fisheries industry has suffered from a decrease of inshore resources because of being over fished during the War ; hence the fishing grounds have been extended a far distance in the pelagic seas. By the use of skillful techniques and large sized fishing vessels the catch has increased and is brought to the mainland under refrigeration. It is then manufactured into various products in order to increase its worth. It is important that the inshore resources be restored to their former level. For this purpose, artificial fertilization of fish or shellfish, conservation of marine organisms, and the discovery of suitable areas to culture useful marine creatures are now under study in Japan.

Efforts are being made to improve and extend the utilization of marine products for food purposes. Raw materials which have been hitherto considered unsuitable for processed articles must be studied. The possibility of changing their properties to make them fit for processing into useful products must be considered. For example, Alaska pollack which are caught abundantly has been considered unsuitable as raw material of fish paste ("Kamaboko") owing to the loss of elasticity of the meat after processing, methods of utilizing this fish for such a product must be studied, because with the increased production of fish sausage, a serious shortage of raw material has developed.

On the other hand, saury (mackerel-pike) or squid which are caught abundantly in the fishing season must be studied for utilization as food. If many cold storage warehouses are established, almost the entire catch could be accommodated, but off-season uses for such cold storage plants would have to be developed. The number of cold storage plants is naturally governed by the economics of the business. Thus, raw material which can not be accommodated in such available storage facilities must be utilized promptly for other products. Therefore the related technical problems must be studied. At present, the fish which are caught abundantly at one time, are utilized for canning or manufacturing fish scrap beside storing as frozen fish. Efforts must be made to utilize for human food or at least for live stock feed almost all the fish scrap which is now used as fertilizer.

With the change of living mode, new styles of frozen or seasoned fish meat should be created. In particular new styles of packaged foods can be designed following the development of new kinds of plastic film. Canned foods processed for export are maintained at top level quality. Furthermore inexpensive and good quality canned marine products for domestic consumption must be prepared from the fish which are caught so abundantly.

Products such as dried squid, dried abalone have found an export market in China from olden times owing to their good qualities. However, products such as dried cod cannot be prepared satisfactorily by natural drying owing to the relatively high humidity of the air in this country. Thus artificial methods of drying cod should be investigated.

Heavily salted products have been held in high esteem by country people for many years. More recently light salting techniques have been developed and products so prepared must be held in cold storage until consumed. The technical problems concerning salted foods have been largely overcome in Japan.

It is important to utilize the waste products in the fishing industry. The waste products from floating canneries are made into fish solubles and fish meal. The waste products in the land-based factories are utilized step by step thus eliminating the problem of collecting waste products. However, the desired level has not yet been achieved. It is essential that fish solubles or fish meal be of good quality. Fish solubles are absorbed on wheat bran and dried to make S.P. (soluble protein) feed. An increase in production of fish solubles and fish meal is anticipated. In making fish meal or flour for human consumption only edible proteins of the fish should be employed.

REFRIGERATION AND COLD STORAGE OF MARINE PRODUCTS

I. General View of Refrigeration of Marine Product

The development of the refrigeration industry in Japan has been dependent upon the growth of the fisheries industry, thus the existing refrigeration facilities are almost exclusively utilized for fishery products. The annual increase in the number of ice-making plants and cold storage facilities (including freezing plants) is shown in Table 3-1.

Table 3-1. Annual increment in numbers of ice-making, cold storage and freezing plants

Year	Total number of plant	Ice-making plants		Cold storage plants		Storage of ice		Freezing plants	
		No. of factory	Capacity (t/d)	No. of factory	Capacity (m^3)	No. of plant	Capacity (m^3)	No. of plant	Capacity (m^3)
1964	2,974	1,762	30,571	2,939	5,016,012	1,738	1,087,310	1,208	14,596
1965	3,024	1,726	30,198	2,995	5,437,062	1,686	1,028,497	1,263	15,219
1966	3,031	1,687	29,677	3,003	5,717,793	1,628	994,112	1,307	16,162
1967	3,079	1,662	29,451	3,050	6,203,466	1,588	936,591	1,361	17,203
1968	3,171	1,621	28,868	3,153	7,187,338	1,519	898,904	1,428	18,923

Table 3-2. The distribution of refrigeration facilities in Japan (1968)

	Total number of plants	Ice-making plants		Cold storage plants		Storages of ice		Freezing plants	
		No. of plants	Capacity (t/d)	No. of plants	Capacity (t/d)	No. of storage	Capacity (1,000m^3)	No. of plants	Capacity (t/d)
Grand total no.	3,171	1,621	28,868	3,153	7,187	1,519	898	1,428	18,923
Region of Hokkaido	350	97	1,528	350	842	88	69	314	6,032
〃 Tohoku	631	266	3,790	627	1,044	235	171	360	4,495
〃 Kanto	537	267	5,869	533	1,764	251	162	266	2,763
〃 Chubu	364	275	3,819	596	998	323	110	231	1,965
〃 Kinki	364	229	4,540	356	1,441	202	161	80	963
〃 Chugoku	240	156	2,873	238	360	150	67	59	570
〃 Kyushu	299	191	5,375	297	567	174	103	82	966
〃 Shikoku	126	90	1,079	126	170	86	33	36	269

The distribution of the number of facilities throughout Japan in 1968 is shown in Table 3-2.

Apart from Table 3-2, as to the smaller unit of Prefectures than region unit, Hokkaido has the largest number and capacity of such plants, this is due to the fact that Hokkaido is the most important landing-place for fish.

As shown in Table 3-2, there were 1,428 freezing plants in 1968, with capacity of 18,923 tons per day. If these freezing plants were completely used, 6,640 thousand tons of marine products could be frozen per year. This amount is approximately three quarters of the total catch for one year, namely 8.6 million tons. The actual annual amount of frozen marine products was 2,355 thousand tons in 1968 as shown in Table 3-3, and is about a half of the total production of marine products, and is the highest proportion in the past five years. The recent rapid increase of the frozen products depends on completion of cold-chain system and development of freezing at sea.

Table 3-3. Annual production of frozen marine products (1,000 tons)

Year	Amount of frozen marine products (A)	Total amount of marine products (B)	$\frac{(A)}{(B)}$ (%)
1964	1,352	3,381	39.9
1965	1,799	3,927	45.8
1966	1,825	4,055	45.6
1967	2,021	4,384	50.0
1968	2,355	4,994	56.0

Itemized data on frozen marine products in 1968 are shown in Table 3-4.

Table 3-4. Production of frozen marine products in 1968 (tons)

Kinds of frozen products	Amount of frozen product
Sardine	92,217
Herring	54,652
Atka mackerel	21,025

Kinds of frozen products	Amount of frozen product
Saury	102, 890
Squid	386, 120
Mackerel	299, 944
Flounder, halibut	50, 135
Sea breams	27, 426
Cod and Alaska pollack	46, 239
Skip-jack	13, 813
Tunas	267, 791
Sword fish	24, 741
Shellfish ligament (e.g. scallop "eye")	386, 192
Whale meat	139, 496
Raw fish paste "Surimi"	153, 841
Others	471, 884
Total	2, 355, 710

II. Export of Frozen Marine Products from Japan

The total export of frozen marine products was valued at 90 million dollars in 1968 according to the statistics of the Ministry of Agriculture and Forestry. This is about 26% of the total amount of the export of marine products, 350 million dollars.

The amount of exported frozen marine products in 1962 is shown in Table 3-5.

Table 3-5. Exports of frozen marine products in 1968

Kinds of frozen marine products	Amounts (tons)
Tunas	107, 084
Skipjack	7, 747
Seabream	9, 494
Others	98, 577
Total amount	222, 902

Of the total amount of export (90 million dollars), frozen tuna occupied about 45%.

The countries of destination of frozen tura are U. S. A. (36,370 tons), Puerto Rico (27,630 tons), Italy (24,955 tons) and others.

Frozen tuna is the most important export of the frozen marine products in Japan.

III. The Kinds of Frozen Marine Products and their Styles in Japan

The frozen marine products exported from Japan are albacore, yellowfin tuna, big eye tuna, blue fin tuna, skipjack, shark, swordfish, rainbow trout, halibut, seabream, eel, shrimp, crab, squid, octopus, scallops, clams, and frog, etc. These materials are exported in various forms (in shape and size) according to their preliminary handling (e. g. gutting or cutting).

According to the preliminary handling procedures, the following names are given as shown in Table 3-6.

Table 3-6. The names of frozen fish by preliminary handling

Preliminary handling	Names of prepared fish
None	Round fish, whole fish
Gutted and eviscerated (sometimes scales are removed)	Semi-dressed fish
Gutted, eviscerated and beheaded (sometimes scales are removed)	Dressed fish
Gutted, eviscerated, beheaded and fins removed (sometimes scales are removed)	Pan-dressed fish
Cut fish body in round slices (about 1.5cm) (usually skinned)	Steak fish
Cut fish body in round slices of large size	Chunk fish
Filleted fish body (usually skinned)	Fillet

Recently new styles of frozen tuna have appeared. For example, frozen loin of tuna is prepared as follows: Raw tuna is filleted, the fillets are cut along the lateral line and steamed and are then frozen.

Frozen disc of tuna is prepared as follows: Filleted raw tuna meat is steamed and is cut to can size shape and is frozen. Frozen fish block (fish slab) is prepared by gathering fish fillet meat of one kind or of two or more kinds of fishes and by compressing to plate-shape and at last is frozen. The former is called "single fish block," and the latter is called "assorted fish block". When the fish block is cut in a rectangular shape of various sizes and is frozen, this small rectangle pieces are called "fish sticks". When the fish block is cut in a bar-shape and is frozen, it is known as a "fish bar."

Frozen fish for domestic consumption are generally prepared in "round fish" style. But with the present day change of living conditions, new styles of frozen fish, e.g. "Prepared frozen fish," "ready-to-cook frozen fish" or "precooked frozen fish" are becoming popular. Such prepared frozen fish products can be conveniently used by house wives. For example, among "ready-to-cook frozen fish" Japanese style "seasoned fish meat", such as roasted eel ("Unagino-kabayaki"), or "fried oysters" are frozen. Fish sticks as described above are coated with wheat flour and bread flour and are then frozen. This is called "breaded fish sticks." When the breaded fish sticks are fried prior to freezing, they are called "fried fish sticks." In Japan frozen fish sticks are extensively used in the school lunch program.

IV. Freezing Procedures in Japan

1. **Freshness of raw material**

In order to prepare good quality frozen fish, only fresh raw materials should be used. If the raw materials used are not fresh, even if the succeeding handling and treatment are skillfully done, good quality frozen fish can not be obtained. Then, how is the degree of freshness of raw materials determined for frozen products? Frozen fish is used in the same manner as raw fresh fish, so the shorter the holding time after the catching the better. The ideal storage of freshness of raw materials for freezing is that before or during the rigor mortis. Thus it is important to prolong the time before reaching the stage of rigor mortis. In order to extend that time, or the duration of rigor mortis, the raw materials should be held at or near 0°C with fine crushed ice.

2. Preliminary handling aboard boats

On small inshore-boats the catch of fish usually receives no preliminary chilling, but is sometimes covered with tarpaulins or other covering and promptly brought ashore. Many species of fish are usually brought ashore in the "round", because the catch is too great to gut or behead aboard ship. When the boats remain out for several days, crushed ice is carried and when the fish are caught, they are packed in the ice.

3. Washing and panning

When the fish boats arrive at the freezing plants, the fish are landed. After the landing, the fish are inspected and graded by size and quality for acceptability. Then the fish are handled according to their end use. Such as; round, semi-dressed, dressed, fillets, steaks or sticks, etc.

If fish are in the "round," they are washed. If fish of large size are dressed, they are beheaded, gutted and eviscerated and the bits of kidney and blood are removed by hand, sometimes with the help of brushes. After dressing, fish are washed by means of a hose. They may also be washed by turning a hose into the belly cavity or by being placed in water tanks. Sometimes knives having a hose in their handles are used for eviscerating. Larger fish go directly to a sharp freezer after being washed. Nearly all smaller fish are panned. Fish to be panned are washed in a water tank. Fresh water is most commonly used. The panning tables are located adjacent to the washing tank.

The pans are of 20- to 22-gauge galvanized iron; the sizes of the pans

Table 3-7. Regulated sizes of pans in Japan

Names	Content	Lengths of upper end of pan (mm)	Length of bottom of pan (mm)	Depth of pan (mm)	Thickness of galvanized iron
5 kg pan	5 kg	260×360	250×350	75	×22
10 kg pan	10 kg	360×580	345×565	75	×22
15 kg pan	15 kg	410×680	395×665	75	×24

are regulated by the Japanese Association of Refrigeration as shown in Table 3-7.

In any event the pans should produce cakes which will fit the final packing box. Some pans have a few holes in the bottom to permit drainage of water, slime and blood. Usually the pans have sloping sides (the inclination is known by the difference between lengths of upper end and bottom of the pan) to facilitate removal of the frozen cake.

The fish are placed in regular arrangement in the pans, the arrangement depending on the size and shape of the fish. It is good to pack fish with bellies exposed, at least on one side. In order to make a firm cake it is desirable to pack the fish in the pans so that they are pressed firmly together. However, too close packing makes separation of the cakes difficult or impossible. When the pans are packed, they are placed on trucks and carted to the sharp freezers.

In order to prevent desiccation, rusting and loss of flavor, frozen "round fish" or frozen cake are ice-glazed. If the fish, while frozen, are dipped into cold water and withdrawn into the air of a cold room, the adhering film of water freezes, forming a transparent coating of clear ice surrounding and adhering firmly to the fish. The ice glaze brightens the color of the fish and overcomes many disadvantages of frozen fish as long as it remains intact. In Japan, a short trough (glazing-tank) (about 1.5×0.8×0.4 meter) is employed.

The cakes of frozen fish are removed from pans by briefly dipping the pan in clear water to defrost the outside of the cake. The removed cake is immersed in the glazing-tank containing water for 1/2 to one minute. The room, in which the glazing tank is placed, should be at a temperature of -9.4°C -11.1°C.

The cakes are then weighed, boxed and stored, or else stored without boxing. In some freezers a movable glazing tank (trough) is taken into the storeroom and the cakes are glazed and stored immediately.

4. Filleting and packaging

Fillets or steaks which are now produced in Japan include whale meat (lean meat, fatty tail meat, ventral groove meat), tuna and swordfish (yellow fin tuna, blue fin tuna, albacore, big eye tuna, white marl, broad swordfish, giant black marlin, sailfish), flat fish (flounder, halibut), sharks (great blue shark, dog fish), rock fish, cod, Alaska pollack and salmon, etc. Fillets are obtained by cutting the flesh from one side of the backbone the length of the fish starting just behind the head, then turning the fish over and cutting a similar strip of flesh from the other side of the backbone. Some fillets are skinned, others marketed without skinning. Larger fish, such as salmon, swordfish and tuna are not usually filleted, but are cut crosswise into "steaks" each a little more than 1.5cm in thickness.

Fillets or steaks absorb too much salt when they are frozen by immersion in or spraying with brine. Thus they are packaged and then frozen by one at the quick freezing systems. Of the newer quick freezing procedures, contact freezers are frequently employed in Japan.

Since filllets and steaks are difficult to glaze satisfactorily, it became necessary to perfect both wrappers or packages which would retard desiccation and oxidation during frozen storage. Ordinary vegetable parchment paper, cellophane or waterproof papers do not disintegrate in water, but permit so much moisture-vapour to pass through them that frozen fish fillets wrapped therein desiccate and oxidize rapidly. For this reason, the sheeting used for wrapping fillets for freezing is usually coated with a plastic film (high density polyethylene or vinyliden chloride film) which is moisture-vapour-proof.

In Japan, filleting is mostly done by hand, but recently filleting machines have been imported or designed in this country. A large proportion of the fillets are skinned prior to packaging. In many plants the skinning is done by hand. But this operation is now being done to some extent by skinning machines which have been imported or designed in this country.

After filleting and skinning, the fillets are sometimes immersed in a brine containing 3 to 15 per cent salt for from 20 seconds to 2 minutes. Pure salt solution is more effective in preventing drip than brine relatively high in calcium and magnesium salts and sulfates. Furthermore, fillets treated with pure brine retain their good flavour much longer than those dipped in impure brine (containing other salts) or than those without such an immersion treatment. The brined fillets are drained and transferred to packing tables.

Packaging is done by hand or machines with vegetable parchment paper or polyethylene film. Packaged fillets are quickly frozen in a contact freezing system. Some frozen fillets are packed in 5-, 10- or 20 pound waxed paper board or fibreboard cartons, and the packed boxes are kept in frozen storage. Sometimes, after being individually wrapped in moisture-proof vegetable parchment, cellophane or polyethylene film, fillets are packed in 10-, 20-, or 30- pound wooden boxes for "sharp" freezing.

5. Anti-oxidative treatment

As above stated, fillets and steaks are difficult to iceglaze satisfactorily, therefore, fillets and steaks are usually wrapped. In order to prevent the rusting of frozen fish, they are sometimes treated with an anti-oxidant. When fish fillets are immersed in a brine before freezing, rusting is a frequent problem. In this case, an anti-oxidative treatment should be employed. As anti-oxidants ascorbic acid and its isomer (iso-ascorbic acid; erysorbic acid) or B.H.T. (butyrated hydroxy toluene) and B.H.A. (buthyrated hydroxyanisole) are used. Ascorbic acid and its isomer are soluble in water, while B.H.T. and B.H.T. are insoluble in water, but soluble in alcohol. When B.H.T. and B.H.A. are used, those reagents are dissolved in alcohol and the alcoholic solution is diluted with water. Ascorbic acid and its isomer are especially effective for preventing a red discoloration of the fish surface.

6. Freezing fish at sea

If fish are caught on vessels at a considerable distance from shore and more than 30 days pass prior to landing, they become stale if kept packed only in ice. Therefore the fish must be frozen on ship board promptly after capture.

The number of Japanese fishing boats having refrigeration equipment is shown in Table 3-8.

As seen in Table 3-8, many tuna fishing vessels and large trawlers have refrigeration equipment.

In former times tuna-fishing vessels chilled fish with crushed ice. Recently the majority of the vessels have employed a chilling method which consists of circulating cold sea water. When hauled in, the tuna are placed in tanks through which chilled sea water (-2.2°C) is rapidly circulated. When the fish have been brought down to a temperature of about 0°C, they are placed in the fish hold where they are kept with crushed ice.

When the fishing grounds are at a considerable distance from shore and more than two months pass prior to landing, the method of chilling with cold sea water is not sufficient, so refrigeration equipment must be employed. At the present time, smaller tuna fishing vessels (less than 350 gross tonnage) have employed a semi-air-blast system. The larger tuna fishing vessels (more than 1,000 gross tonnage) have employed a brine freezing system (e.g. Ottesen's method) or a contact freezing system, because the catch is likely to be over 30 tons in a day.

Table 3-8. Number of Japanese fishing boats having refrigeration equipment

Kinds of boats	Total number	Trawlers	Large trawlers west of 130°E	Tuna fishing boats	Salmon fishing boats	Others
1959	1,089	41	76	685	85	202
1961	1,523	40	84	986	183	230

Recently three floating-factories (7,000~12,000 gross tonnage) after completing salmon fishing in northern sea ("Hokuyo") for the season, go the southern Pacific Ocean. They are each accompanied by about 30 tuna-fishing boats for tuna-fishing. They freeze the catch by a contact freezing system from September to March and come back to Japan keeping the catch in frozen storage.

Large Japanese trawlers are usually equipped with a contact freezer. Iwamoto's contact freezer is usually used. The contact freezer is effective on a vessel even when it is pitching and rolling during rough weather.

V. Freezing System

Various freezing systems have been employed in Japan. They may be classified into the following groups:

(1) Sharp freezing
(2) Air-blast freezing
(3) Contact freezing
(4) Immersion freezing

1. Sharp freezing

Sharp freezing is to freeze foods in cold air of -25° ～ -30°C. By this method it takes a long time to freeze the inner parts of the products completely, but the equipment and treatment are relatively simple and not so expensive. Therefore almost all of the freezers in Japan are of this sharp freezing type.

The sharp freezer is a room which is usually much smaller than a cold storage room. Such a room is generally 3. 2 ～ 3. 6 meters wide, 3. 6 ～ 10 meters long and 3. 5 ～ 4 meters high. Along both sides of the room, the refrigeration pipes are arranged to make banks of shelves consisting of 10 ～ 20 steps, 0. 8 ～1 meter wide. One step of the shelves consists of 6 ～ 8 horizontal pipes. Each three shelves are connected with a multi-feed and multi-suction type header or cascade type header. As these banks of shelves of refrigeration pipes are not completely sufficient to freeze the products, refrigeration pipes of 1 1/4 inch or 2 inch diameter are fastened to the ceiling. The length of the pipes in a sharp freezer of which the frontage is 3. 2 meters, and the number of the steps of the shelves are 12, as shown in Table 3-9.

Panned fish are placed on the shelves. When large fish such as salmon, tuna or swordfish, etc. are frozen, the shelves must be farther apart and covered with sheets of 14-gauge galvanized iron. The fish are either laid on the shelves, or else, as is done in some places, on the floor or on slatwork along the floor. In front of the sharp freezer, there is a precooling room, in which glazing or other treatments are carried on. In Japan, there are some large sharp freezers where brine is circulated through the pipes. In such a sharp freezer relatively well-

Table 3-9 Length of pipes in a Japanese sharp freezer of which frontage is 3.2 meters, and the steps of shelves are 12

Depth of sharp freezer	Length of pipe (1 1/4 inch) arranged to make shelves	Length of pipe (2 inch) on the ceiling	Capacity
meters	meters	meters	tons
3.6	390	70	2.4
4.5	520	73	3.2
5.5	655	82	4.05
6.4	790	82	4.8
7.3	920	83	5.7
8.2	1050	95	6.5
9.1	1170	98	7.3
10	1310	100	8.1

preserved fish can be prepared and also the time of freezing can be somewhat shortened. There are many small freezers, in which direct expansion is employed.

2. Air-blast freezing

As the air in the sharp freezer does not circulate, the rate of freezing is not rapid. In order to accelerate the rate of freezing, air-blast freezers were invented, in which cold air is circulated into the room. The temperature of the cold air is -35° ~ -40°C. This temperature is attained by a two-stage compression refrigeration machine. The air velocity is 3~5 meter/second in the freezer, the greater the velocity, the more rapid the freezing. A cold air-blast is usually obtained by directing air from a blower through coils refrigerated by ammonia or "Freon." The quality of frozen fish prepared by air-blast freezing is good. As the construction cost of such air-blast freezers is great, the semi-air-blast freezers are usually and widely employed in Japan.

3. Semi-air-blast freezing

A semi-air-blast freezer is a sharp freezer in which air is kept moving (air-velocity is 2~1.5 m/second) by an electric fan. By use of a semi-air-blast freezer, the freezing time is about a half of that realized in an ordinary sharp freezer. The temperature of the freezing room can be kept -30°C, when there is no refrigerating charge in the room (without freezing raw material). Therefore there is no need to have a two-stage compression refrigeration machine, and it is sufficient to employ a one-stage compression refrigerating machine for the freezing. Refrigeration pipe must be used having twice the freezing capacity of an ordinary sharp freezer, therefore the length of the pipe attached to the ceiling must be increased. A semi-air-blast freezer has a fault in that the air velocity is not equal in all parts of the freezer. Therefore, the position at which the fan is located must be taken into account. In this freezer, if the air velocity is above 1 meter/second, there is no difference in the time required for complete freezing between freezing raw materials which are left on the refrigeration pipe or are apart from the pipe. Therefore, there is no need for refrigeration shelves. In the freezer, for one ton of raw material to be frozen at one time, it is said that a freezing capacity of 1,000 Kcal/h°C is required.

4. Contact freezing

The contact freezer is the so-called "Cold plate freezer". This is extensively used for the freezing of packaged fillets, steaks and small fish. It consists of number of superimposed refrigerated hollow metal plates (sometimes called "flat tank"), so actuated hydraulically or driven up by screws connecting the metal plates, that they will open to receive products to be frozen between them and will close on the products at any desired pressure. A rubber hose is connected to a header which feeds each plate with ammonia, "Freon" or brine used as the refrigerant. The other end of the plate is also connected by a rubber hose to another header which return the brine or ammonia to the surge drum or to the refrigeration machine.

In Japan, Iwamoto's contact freezer is popularly used aboard vessels. The hollow plates of galvanized iron or aluminum alloy in which rectangular refrigerating pipe is installed, are cooled to -25°C. The plates are held by iron supports (iron rods) having screws, so the plates can be moved up or down by driving nuts inserted in the supports. As the distance between the plates which it is desired to open can be changed by driving the nuts without all the plates being operated, the height of the whole apparatus is low. Therefore, this freezer is the most suitable for use on vessels. The pressure between the plates is sufficient at 0.1 kg/cm^2. When the thickness of the products to be frozen is 6.25 cm, 3～4 hours are required for freezing. Recently some contact freezers using ammonia as the refrigerant, e.g. Amero are being used in this country.

5. Immersion freezing

Immersion freezing means a procedure by which products to be frozen are dipped into cold brine (concentrated sodium chloride solution at -15°C). This freezing system is famous under the name of "Ottesen's method". This immersion freezing is employed usually on tuna-fishing vessels.

A number of larger Japanese tuna-fishing vessels immediately freeze each catch by placing the fish in tanks through which cold sea water (-2.2°C) is rapidly circulated. When the tank has been filled with fish, the chilled sea water is pumped over-board and freezing is effected by circulating brine at about -15°C. The fish are brought down to a temperature of about -18°C, then the cold brine is returned to a surge tank and the fish are held dry at approximately that temperature. By this freezing some salt penetrates into the fish during freezing. The fish frozen by this method is used almost exclusively for canning. When frozen tuna is used for canning, the salt which penetrated into the fish leaches out during cooking, preparatory to canning, and the salt which remains is not considered objectionable.

At a land freezing plant, the dipping of fish as it is in the brine is not carried on, but recently packaged fish meat or poultry are immersed to freeze in brine of -30°C, because the salt does not penetrate into the fish meat due to the packaging.

VI. Frozen Storage

Frozen products treated by various freezing methods are stored in a low temperature cold store room until the products are consumed. Raw products for which freezing is unsatisfactory and which are perishable at room temperature are also placed in cold storage (above -4°C).

In Japan large cold storage plants are grouped into three classes, A, B, and C, according to the storage temperatures as shown in Table 3-10.

The lower the temperature of the cold storage is, the better the quality of frozen products can be kept. Recently frozen products are kept below -23°C (this is called Extra A class).

In some cold storage rooms, unit-cooler is installed hanging to the ceiling or on the floor in order to circulate cold air uniformly. In this case, sometimes an air tunnel is connected to the unit-cooler. If this air-circulating method is employed, the products will be more or less desiccated, unless adequate protective packaging used.

Large unboxed fish, such as large quantities of salmon or Alaska pollack are stacked in the rooms. When large quantities of fish are

Table 3-10. Classification of cold storage establishments by storage temperature

Class	Storage temperature	Products stored	Thickness of insulating material (as cork board)
Extra A	Below -20°C (Ordinarily -23°C)	Frozen fish, frozen meat, ice-cream	mm 175
A	-12°～-20°C (Ordinarily -15°C)	Frozen fish, frozen meat	150
B	-12°～-4°C (Ordinarily -9°C)	Frozen eggs, butter (long period) dried filleted herring meat ("Migaki-nishin"), frozen cod roe, frozen salmon roe, split cod meat, salted herring roe, salted salmon, ham, cheese, smoked fish	125
C	Above -4°C (Ordinarily -4°C)	Seasoned foods, dried herring roe, salted and dried fish, ray fish (short period), roasted bonito ("Namari-bushi"), "Tsukudani", raw fish roe, raw shrimp, fruits, raw meat, dried bonito("Katsuo-bushi"), "Kamaboko", milk, vegetables, wines, butter (short period), condensed milk, tea, fur goods, wollen cloth	100

stored, the room is filled up to the ceiling in such a way that the fish do not quite come in contact with the floor and side walls. The stacked fish must be sometimes reglazed. High grade fish are sometimes wrapped in parchment paper before being boxed. Boxes make reglazing more difficult. If boxed fish are to be reglazed, the boxes must be opened and the fish dipped into a tank of water. Perhaps the most serious objection to storing in boxes is that a very much smaller amount of fish can be stored in the rooms as compared with the storage of unboxed fish.

When fish are frozen in pans, the cakes may either be boxed or stacked unboxed in the store room. If the cakes are stored without boxing, care must be exercised to avoid breaking the tails and snouts in handling.

Table 3-11. Accommodation of products stored per 1 m^3 by the kinds

Kinds of products	Arrangement	Kinds of Container	Size of the container (m^3)	Weight of the content in a container (kg)	Accommodation of products stored per 1 m^3		Remarks
					unit	weight (kg)	
Raw fish	stacked	box	0.07	37.5	10 boxes	375.0	Standard trawler box
Frozen fish	in bulk	—	—	—	—	470～540	
Salted and Dried herring roe ("Kazunoko")	stacked	straw-bag	0.167	94.0	5 bags	470.0	
Beef	hanging	—	—	225/a head	0.822 head	185.0	
Egg	stacked	box	0.056	15.0	11.65 boxes	174.8	
Apple	〃	〃	0.070	18.0	10.00	180.0	Backet can not be stacked by breaking
Onion	〃	〃	0.140	45.0	5.82	261.9	
Cabbage	〃	basket	0.140	37.0	4.32	162.0	

In Japan, the quantities of products kept in cold storage, after being frozen or without freezing, are measured per 1m³ (inside measurement) as shown in Table 3-11.

If raw fish is stacked without boxing, about 0.4 ton can be stored per 1m³ of store room. So if an average of 70% of the whole inside volume of the store room effective, about 0.3 ton of raw fish can be stored per $1m^3$ of the store room.

VII. Inspection of Exported Frozen Marine Products

In order to export frozen marine products of good quality, the Japanese Government has enacted the "Export Inspection Law of 1957" effective Feburary 1, 1958). The quality standards and inspection procedures for exported frozen marine products listed according to classification No. 2 are as follows.

Japanese Quality Standards and Inspection Procedures for Exported Frozen Marine Products Listed as Classicification No. 2 of The Export Agricultural and Forestry Commodities Designated by The Japanese Government under Export Inspection Law of 1957, Effective February 1, 1958

FROZEN ALBACORE, BLUEFIN, BIGEYE, SOUTHERN BLUEFIN & SKIPJACK (Products, precooked and frozen in the form of loin or disc, excluded)

Appearance

Fish that is not split, minus the head, broken or deformed to such an extent that the flesh excluding blood meat is undesirably affected in whole or in part, is considered to be of good appearance.

Color

Fish that in any portion thereof does not possess any green color associated with green meat, grayish white caused by dehydration, yellowish brown resulting from oxidation, or any other colors not characteristic of the particular species of fish, is considered to be of good color.

Freshness

1. Freshness is judged primarily by means of odor. To evaluate odor the inspector as a rule drills a small hole in a specific part of the flesh and quickly smells the odor coming from the inside. Fish free of such odors as hydrogen sulfide, trimethylamine, ammonia or any other off odor, is judged to be fresh.

2. In the borderline case where it is impossible to judge only by

odor as described above, a series of laboratory tests are conducted by those methods specified in the affixed note for the purpose of finalizing freshness based upon the following criteria.

(1)	Hydrogen-ion-concentration	below pH 6.5
(2)	Volatile basic nitrogen	below 30mg/100g
(3)	Trimethylamine-nitrogen	below 30mg/100g

Foreign substances

Fish that does not contain with sand, soil or other extraneous substances, is accepted as clean.

Glaze

A uniform glaze sufficient to prevent the occurrance of dehydration and oxidation must be present.

Temperature

The temperature be below -10°C at the internal center of the flesh.

PRECOOKED AND FROZEN ALBACORE, YELLOWFIN, BIGEYE, SOUTHERN BLUEFIN & SKIPJACK (Products, precooked and frozen in the form of loin or disc)

Texture

The texture of the flesh should possess a reasonable firmness and elasticity and honey-comb or honey-comb-like tissue must not be present.

Color

Flesh that any portion thereof does not possess any green color associated with green meat, brown color either caused by oxidation or originating from dark meat, grayish white coming from dehydration, off color (discoloration) resulting from blood or any other factors which is not characteristic of the processed product, is considered to be of good color.

Freshness

1. Flesh must possess the good flavor characteristic of such products of the particular species of fish.

2. The flesh that does not possess any odor of hydrogen sulfide or other odors which are alien to the particular species of fish, is judged to be fresh.

3. In borderline cases where it is impossible to determine freshness by the above two means, a series of laboratory examination are conducted

by those methods specified in the affixed note for the purpose of ascertaining freshness based upon samples collected from suspected products. For this purpose, 5 ml. of pressed juice is prepared from individual samples. If the volatile reducing substances contained in such juice are below 20 microequivalents, the flesh so sampled is considered to be fresh.

Appearance

1. Blood meat, bones, skin and scale or any other extraneous substances must not be present.

2. In the case of discs, the surface and edges must be even and smooth, and the pieces of flesh constituting a disc must be compact and contain no crevices.

Glaze

Individual products must be glazed sufficiently and even enough to prevent occurrance of dehydration and oxidation.

Temperature

The temperature must be below -10°C at the internal center of the product.

FROZEN SWORDFISH, BLACK MARLIN AND GIANT BLACK MARLIN (Inclusive of Round or Whole Fish, Chunks, Fillets and Steaks)

Appearance

1. Irrespective of round or whole fish, chunks, fillets or steaks, the shape should be such as will be generally acceptable to the trade.

2. In case of fillets, the neck bone, fins and tail must be completely removed.

3. Such scars as may be left by removal of parasites, green meat or jelly as well as harpoon marks and other defects in the flesh, must be minimum.

Color

The flesh, white or light pink, that in any portion thereof does not possess any green color denoting green meat, yellowish brown resulting from oxidation or any other color, offcolor (discoloration) caused by bruise (internal bleeding) or dull milky white color arising from dehydration, is considered to be of good color.

Freshness

1. Flesh that does not possess such off-odors as of hydrogen sulfide, ammonia or others which are not characteristic of the particular species of fish, is judged to be fresh.

2. In the borderline case where it is impossible to evaluate odor as is described in the foregoing paragraph, a series of laboratory examinations are conducted by those methods specified in the affixed note for the purpose of judging freshness based upon the following criteria.

(1)	Hydrogen-ion-concentration	below pH 6.5
(2)	Volatile basic nitrogen	below 30mg/100g
(3)	Trimethylamine-nitrogen	below 30mg/100g

Foreign substances

Flesh that does not contain blood spots, pieces of skin or other extraneous substances, is accepted as clean.

Glaze

The glaze is required to be crystal-clear and sufficiently thick and even to prevent the occurrance of dehydration or oxidation. Glazing is not required in cases where adequate protective packaging is employed.

Temperature

The temperature is required to be below -10°C at the internal center of the flesh.

FROZEN FROG LEGS AND FROGS (Bull Frog and Japanese Frog)

Description

1. Legs to be processed are the section of a pair of hind legs separated from the trunk at the point where the muscle rectus formis anticus and the gluteus join together in the region of waist. The muscle rectus abdominis, if remaining, should completely be removed from the legs.

2. Whole frogs to be processed are the section of the trunk and a pair of hind legs, with the head cut off from the region immediately behind the ear and also the fore legs removed.

3. In the case of either legs or whole frogs, the fore part of the foot is required to be neatly trimmed along such a line as well, starting from a point between the phalanges and metatarsal bones of the first finger, be drawn approximately at right angle to the vertical leg line.

Appearance

The section of legs is required to be stretched and fixed in the original form which renders a good appearance and to be free from small spear marks, bruises or any other defects in the flesh and also from any fractures in the bone.

Color

Flesh that in any portion thereof does not possess such dark tones as dark green or dark red, dull milky white arising from dehydration or red tones denoting the blood remaining in the flesh, is considered to be of good color.

Odor

The flesh is required to be free from such off-odors as ammonia and any others which are not characteristic of the particular species of frog.

Uniformity

The size in a specific assortment is required to be uniform for the most part and the mixture of any different species is not permitted.

Parasites

Either legs or whole frogs in which parasites are found must be destroyed on the spot.

Foreign substances

Flesh that is not contaminated with small pieces of flesh, blood spots and any other extraneous substances, is accepted as clean.

Glaze

The glaze is required to be crystal-clear and sufficiently thick and even to prevent occurrence of oxidation and dehydration. Glazing is not required in cases where adequate protective packaging is employed.

Temperature

The temperature is required to be below -10°C at the internal center of the flesh.

FROZEN SALMON AND TROUT (Round Fish)

Appearance

Fish that holds its original form without having such defects as will adversely affect the flesh and, any conspicuous loss of the scales, is considered to be of good appearance. In the case of eviscerated fish, it is required that the kidney be completely removed without leaving any remains in the belly and the wall membrane of the belly cavity should be contact with the abdominal bones.

Color

Fish that possesses a color characteristic of the particular species without any presence of the yellowish brown resulting from oxidation in the abdominal section and the grayish white caused by dehydration in any portion of the fish, is considered to be of good color.

Odor

The flesh of fish is required to be free from off-odor as those caused by oxidation and others that are not characteristic of the fish.

Uniformity

The size in a specific assortment is required to be mostly uniform. Mixture of different species is not permitted.

Foreign substances

Fish that is not contaminated with blood and any other extraneous substances is accepted as clean.

Glaze

The glaze is required to be crystal-clear and sufficiently thick and even to prevent occurrence of oxidation and dehydration. Glazing is not required in cases where adequate protective packaging is employed.

Temperature

The temperature is required to be below -10°C at the internal center of the flesh.

FROZEN SCALLOPS

Appearance

1. The scallop, individually frozen, that holds its original form without being substantially split or broken, is considered to be of good appearance.

2. A cake of scallops frozen en masse that is not deformed or cracked is considered to be of good appearance.

Color

Scallops that possess a bright milky white, light creamy white or light pink color without the any presence of the dull shade caused by dehydration are cosidered to be good color.

Odor

Scallop that possess a characteristic fresh odor as are considered to be of good quality.

Uniformity

1. The size in a specific assortment is required to be mostly uniform.
2. Mixture of any scallops different in color is not permitted.
3. Mixture of any different species is not permitted.

Foreign substances

Scallop that are not contaminated with sand, broken pieces of shell or any other extraneous substances, are accepted as being clean.

Glaze

The glaze is required to be crystal-clear and sufficiently thick and even to prevent occurrence of oxidation and dehydration. Glazing is not required in cases where adequate protective packaging is employed.

Temperature

The temperature is required to be below -10°C at the internal center of the flesh.

FROZEN SHRIMP

Appearance

1. Shrimp, individually frozen, that holds its original form without being substantially split or otherwise broken, are considered to be of good appearance.

2. A cake of shrimp, frozen en masse that is not deformed or cracked, is considered to be of good appearance.

Color

1. Shrimp that possess such colors as are characteristic of the particular species are considered to be of good color. Not-withstanding, in case of "Taisho Ebi" (*Penaeus orientalis*), the presence of a slight degree of red color in whole or in the dark in a portion of the tail, is permitted.

2. In case of the shrimp precooked and frozen, there should be no blue color denoting blue meat or any other off-colors in any portion thereof.

3. In either of the above case the presence of the grayish white caused by oxidation and dehydration is not permitted.

Odor

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Shrimp is required to be free from such an off-odor as hydrogen sulfide, ammonia or any others that are not characteristic of the particular species.

Uniformity

The size in a specific assortment is required to be mostly uniform. Mixture of any different species is not permitted.

Foreign substances

Shrimp that are not contaminated with sand, small pieces of flesh or any other extraneous substances accepted as clean.

Glaze

The glaze is required to be crystal-clear and sufficiently thick and even to prevent occurrence of oxidation and dehydration. Glazing is not required in cases where adequate protective packaging is employed.

Temperature

The temperature is required to be below -10°C at the internal center of the flesh.

FROZEN CLAMS (Baby Clams and White Clams)

Appearance

1. Individual clams that hold the shape characteristic of the particular species, are considered to be of good appearance.
2. A cake of clams, frozen en masse that is not deformed or cracked in the most part is considered to be of good appearance.

Color

Clams that possess the color characteristic of the particular species without the presence of the grayish white caused by dehydration, oxidation or of any other off-colors are considered to be of good color.

Odor

Clams are required to be free from such an off-odor as ammonia or any others that are not characteristic of the particular species.

Uniformity

The size in a specific assortment is required to be mostly uniform. Mixture of different species is not permitted.

Foreign substances

Clams that are not contaminated with sand, broken pieces of shell or any other extraneous substances are accepted as clean.

Glaze

The glaze is required to be crystal-clear and sufficiently thick and even to prevent occurrence of oxidation and dehydration. Glazing is not required in cases where adequate protective packaging is employed.

Temperature

The temperature is required to be below -10°C at the internal center of the block.

OTHER FROZEN FISHES

Appearance

Irrespective of round or whole fish, chunks, fillets, steaks or any other styles, the shape is required to be such as will generally be acceptable to the trade and the flesh or meat is required to be free from any defect that is commercially objectionable.

Odor

The fish or meat are required to be free from off-odors such as those of ammonia or any others which are not characteristic of the particular species.

Uniformity

The size in a specific assortment is required to be uniform on average. The mixture of any different species is not permitted and although of the same species, fish if having a different color, is, also, not permitted.

Foreign substances

Contamination with earth, sand or any other extraneous substances is not permitted.

Glaze

The glaze is required to be sufficient and even to present occurrance of oxidathon or dehydration. Glazing is not required in cases where adequate protective packaging is employed.

Temperature

The temperature is required to be below -10°C at the internal center of the flesh or meat.

NOTE

1. Determinations of (1) hydrogen-ion-concentration (pH), (2) volatile basic nitrogen and trimethylamine-nitrogen and (3) volatile

reducing substances are made, respectively, by the following methods, based upon samples collected from the individual suspected fish or products.

(1) pH by glass electrode pH meter

(2) Volatile basic nitrogen and trimethylamine nitrogen method of Conway

(3) Volatile reducing substances-method of Farber

(Note: E. J. Conway: Microdiffusion Analysis, London, 1959; L. Farber and M. Ferro: Volatile reducing substances and volatile nitrogen compound in relation to spoilage in canned fish, Food Technol., 10, 303-4, 1956)

2. Unless otherwise specified by the Export Inspection Law of 1957, the quality standards and inspection procedures will be governed by the relevant provisions of the Food Sanitation Law, as amended, of 1947.

3. Sampling Procedure: Whether or not a specific lot comes up to the inspection standards will be decided based upon the samples which are drawn at random at the specified sampling rates in proportion to the sizes of lots to be inspected as shown below.

a. Albacore, Yellowfin, Bluefin, Bigeye, Southern Bluefin and Skipjack (precooked and frozen products excluded), and Swordfish, Black Marlin and Giant Black Marlin (chunk and steak excluded), and Shark notwithstanding, in the cases where the operation of sampling

Size of lot (Pieces)	Count of Samples (Pieces)
Below 61	all
61 to 100	60
101 to 200	85
201 to 300	100
301 to 400	110
401 to 500	115
501 to 600	120
601 to 800	125
801 to 1000	130
1001 to 2000	135
2001 to 4000	140
4001 up	145

inspection is impossible due to improper storage or that the samples drawn at the above specified rates fail, in part or whole, to come up to the standards, an overall inspection will be conducted.

b. Products other than (a) group, which are packed in boxes, cases or any other casings.

Size of lot (packages)			Count of Samples (packages)
		Below 5	1
5	to	50	2
51	to	100	4
101	to	200	5
201	to	300	7
301	to	400	8
401	to	500	9
		501 up	10

Out of the individual packages thus sampled, a portion equivalent to twenty (20) percent of the contents or four (4) small inner boxes if so packed, are drawn for inspection.

4. Markings: The commodities passing the export inspection shall be labelled or stamped "PASSED".

VIII. Development of Refrigeration and Freezing of Marine Products

In Japan, natural ice has been sold on a commercial scale since 1864. An ice-making machine was imported from Germany in 1883. The first cold storage was established at Yonago in Tottori Prefecture in 1900. Mr. I. Kuzuhara built many cold storage plants (air-freezers) calling in American engineers in 1918, but he ended in failure in 1926. The Hayashikane Fishing Co. (at present Taiyo Fishing Co.) has employed Ottesen's freezing system since 1923. The Nippon Fishing Co. has employed air-freezers aboard vessels since 1927.

Afterwards the refrigerating industry developed step by step. But it was not until 1940 that frozen foods became important competitors of other consumer-type preserved foods. At the present day, frozen foods as highly acceptable as canned foods continue to be very successful consumer goods.

When fish or shell fish are frozen and stored in cold storage, some scientific and technical problems are known to arise.

In Japan such problems are studied by many investigators. The results are published in "Bulletin of the Japanese Society of Scientific Fisheries" (Vol. 1 (1926)—Vol. 36 (1970) or "The Refrigeration" (Vol. 1 (1926)—Vol. 45 (1970)). Those journals are almost entirely written in Japanese, but the former has English synopsis. There are also many books concerning "refrigeration of foods" written in Japanese.

IX. Scientific and Technical Problems in the Refrigeration and Freezing of Marine Products

1. Thaw rigor of frozen whale meat

When frozen whale meat is thawed, a large quantity of the drip flows out. This is caused by thaw-rigor.(1)(2) Thaw rigor is that condition which exists when very fresh frozen whale meat or warm blooded animal meat (before or during rigor mortis) is thawed; the muscle is contracted abnormally to a half or one-third of its original volume and a large quantity of drip flows out. When this very fresh meat is frozen, it retains the factors connected with rigor mortis during cold storage and when the frozen meat is thawed, the phenomena of rigor mortis appears again abnormally, and the muscle exhibits a marked contraction. In other words, the thaw-rigor is a kind of rigor mortis prolonged by freezing and cold storage, and which appears after the thawing more rapidly than that of normal rigor mortis. Frozen whale meat in which it is feared that thaw-rigor may appear will maintain good quality if it is left at -2 ~ 3°C for 7 ~ 10 days in the air before defrosting. During this holding period, the rigor mortis will be completed while the whale meat is in a partially frozen condition. When the rigor mortis has been completed, the partially frozen meat is thawed in air at 10 ~ 20°C. Thus, the whale meat left a partially frozen condition becomes red in color and good in flavor by acceleration of the aging (ripening) process. This flavor is better than that of whale meat left as it is raw and in which aging has occurred.

A method to remove the peculiar odor of whale meat has been invented. (3) The peculiar odor of whale meat is considered to be generated by ging or a loss of freshness of the meat. In this case the odor of the lood is much stronger than that of the meat. The method(3) which as been invented to overcome this odor problem consists of a ractionated heating of frozen whale meat in order to remove the blood. As to the heat-coagulating point of whale meat proteins, that of myosins s 41 ~ 55°C, that of myogen is 57 ~ 67°C, and that of blood protein s 73 ~ 80°C. In order to remove the blood, fractionated heating is mployed to take advantage of these heat-coagulating properties. First he frozen whale meat is cut into small cubes, and is heated at 70°C or 5 ~ 7 minutes; then the meat proteins (myosin and myogen) heat-oagulate without the flow of drip from the meat, and the uncoagulated lood flows out. After the removal of blood, the meat is heated at 90 ~95°C for 10~15 minutes. Whale meat treated in this manner has ittle or none of the peculiar odor.

2. Browning (or blackening) of tuna and bonito meat

Frozen tuna or bonito meat possessing a red color sometimes becomes ark brown or dark red during cold storage. This is due to the fact(4) hat haemoglobin in the blood and myolobin in the meat, as a esult of oxidation, become oxyhaemoglobin and oxymyoblobin which re brilliant red. Those oxyhaemoglobin and oxymyoglobin become nethaemoglobin and metmyoglobin which are dark brown or dark red (almost black) by action of oxidative enzymes in the meat. These hanges usually happen in raw meat. In frozen meat, haemoglobin in lood is freed by haemolysis, and with the activation of the oxidase he changes take place vigorously. Amongst the various kinds of tuna, ellowfin tuna which lives in warm seas has a strong oxidase system n the meat. Therefore when it is frozen, the meat rapidly becomes rown. On the other hand, bigeye tuna or bluefin tuna meat becomes ark (almost dark). Therefore, when yellowfin tuna is cooled in rushed ice on a tuna-fishing vessel, it must be kept apart from the efrigeration pipes in a fish hold so that freezing may be avoided.

In order to prevent the discoloration of tuna meat, sodium nitrite is added, thus changing haemoglobin or myoglobin to nitroso-haemoglobin or nitroso-myoglobin. Another way to prevent discoloration is the addition of an antioxidant such as ascorbic acid to the tuna meat.

Matsumoto and Matsuda(5) have studied the possible use of liquid nitrogen for control of the discoloration of tuna meat. As summerized in Table 3-12, freezing with liquid nitrogen is effective in preventing the discoloration and other quality changes during the frozen storage as compared with the air freezing.

Table 3-12 Change of the organoleptic qualities during the frozen storage of tuna meat.

Group	Fresh meat	After 1 week	After 3 weeks	After 5 weeks	After 8 weeks
LNF	Bright, pinkish red	No marked change	No discoloration, no rancid odor	No discoloration, slightly rancid odor, good texture	No discoloration, rancid odor, slightly soft
AF	Bright, pinkish red	No marked change	Slightly dark in central portion, slightly rancid odor	Slightly dark, rancid odor, Almost good texture	Marked discoloration, rancid odor soft

It has been known that gamma-ray irradiation may convert metmyoglobin into oxymyoglobin. Yamanaka and Amano(6) have examined the action as to the color improvment of frozen tuna. A dose of 0.2 Mrad is adequate to develop a satisfactory color regeneration without leaving off-flavor of the product. However, the regenerated meat color is only transitory because of the reversible formation of metmyoglobin even under freezing condition at -20°C. Storage condition which enables a sufficient supply of oxygen into the irradiated tuna meat is effective to retain the red coloration. Thus packaging of the irradiated meat with a permeable film such as polyethylene after slicing into thinner fillet may be one of the feasible ways.

3. Green discoloration of tuna meat

Green meat of the broadbill swordfish (*Xiphias gladius*) is caused by the formation of sulfhaemoglobin which results from the chemical combination of haemoglobin with hydrogen sulfide generated by hydrogen sulfide-forming bacteria or by decomposition of the meat.(7)(8) During this reaction, isovalerianic acid is generated, and which produces an unpleasant odor like "salt bran for pickling".

This green discoloration is not only observed in raw meat, but also in frozen meat. It is generally associated with a loss of freshness of the meat. In order to avoid the formation of green meat, the following precautionary measures should be taken: (a) Only fresh raw material should be frozen. (b) Fish should be chilled rapidly after being caught in order to maintain freshness. (c) Prior to freezing the fish should be completely eviscerated and the blood removed. (d) If green meat is found in the frozen fish it should be removed by cutting. (e) If fish having green meat is held at low temperature such as below -18°C, the green meat portion will not enlarge. Thus frozen fish should be kept at a temperature lower than -18°C in cold storage.

When frozen "longfin tuna" (albacore) meat is thawed and boiled, there sometimes results a blue meat of dead color meat. Such meat having become blue or dead color sometimes shows a brown or dark color when it has been thawed. The blue meat or dead color meat has been considered(9) to be caused by a change in the nature of the blood. The occurrence of blue meat is accompanied by an unpleasant odor.

After a number of examinations, Sasano *et al.*(10) have discovered that a certain compound which is occasionally contained in flesh of albacore and yellowfin tuna, and gives a yellow ninhydrin paper chromatographic spot (YS) from alcoholic extracts, is closely connected with the occurrence of green meat. They presumed that the compound might be a sort of peptide and directly associated with develop of green meat of tuna when subjected to boiling.(11) On the other hand, Koizumi and Hashimoto(12) have investigated the YS spot, and found that the compound is trimethylamine oxide (TMAO). Tuna myoglobin turns into the green precipitate bearing a striking resemblance in color to the green tuna on heating with TMAO and cysteine under anaerobic condition.

For the assessment of green tuna, Yamagata *et al.*(14) have developed a simple and rapid TAMO determination method combined with a reduction method, which concerts TMAO to trimethylamine. Using this method, they investigated the distribution of TMAO content in the muscle of yellowfin tuna in order to determine the most suitable sampling portion of the fish. It is recommended that the interior portion of dosal muscles be taken for TMAO determination for the purpose of assessing green tuna before cooking.

There are some investigations on the relation between TMAO content in tuna meat and the degree of coloration after cooking.(15)(16)(17) Discoloration of yellowfin tuna is evident at the levels over 30 mg% of TMAO-N, while off-color of albacore is recognized on the meat containing 10mg% of TMAO-N.(15) Although the presence TMAO is an important factor of greening, it seems that other factors such as myoglobin content and the cooking conditions may also be concerned with the discoloration.(16) When the TMAO-N concentration is below 4 mg%, the cooked meat color is not green but dark brown and the intensity tends to increase with amount myoglobin. When the TMAO-N concentration is 8 mg%, green color is not seen in myoglobin 20 mg%, but a faintly green color is evident in the myoglobin 60~140 mg%. When the TMAO-N concentration is 13 mg%, a green color is seen in myoglobin 60~140 mg%. When the TMAO-N concentration is 30 mg%, a moderately or heavily green color is seen in all cases except for the myoglobin 20 mg%.

Brown *et al.*(18) recognized that sodium hydrosulfite effectively prevents greening of raw tuna which will otherwise develop green on cooking. The reagent is also effective to prevent green discoloration due to TMAO.(15)

4. Jelly meat of broadbill swordfish

Jelly meat found in broadbill swordfish meat is caused(19)(20) by the deformation of meat muscle and by its dissolution to a jelly state by cathepsin or other enzymes which are secreted by *Chloromyxum musculoliquefaciens sp. nov.* and *Neochloromyxum cruciformum gen. et sp. nov.*, kinds of sporozoa, which are parasitic on the fish. This parasitism is said sometimes to occur in diseased swordfish. In order to avoid the formation of frozen jelly meat, the diseased fish should discarded prior to freezing. After freezing, if a portion of jellified meat is found, the part should be removed by cutting. If diseased fish is held at below -18°C, the number of sporozoa present decreases gradually ; hence the fish should be stored at a low temperature.

Jelly meat has also been found in bonito, tuna, common sea-bass (*Lateolabrax japonicus*) and dolphin (*Corphaena hippurus*).(21)

5. Yellow meat of halibut

In halibut meat, a yellow discoloration sometimes occurrs. This discoloration appears to be caused by *Pseudomonas fluorescens* which is a kind of marine bacteria. In order to prevent this discoloration, the body of halibut must be washed with about 20% NaCl solution before the freezing.

After freezing, the halibut should be stored at low temperature without a fluctuation of temperature.

6. Spongy meat in cod

In frozen cod or Alaska pollack meat, spongy meat is sometimes found and its cause is not yet clearly understood.

Tanaka(22) reported that cod or Alaska pollack contains large quantity of air and other kind of gas in their meat muscle, because they are generally living in the deep. He said that in fact, the specific gravity of cod or Alaska pollack meat is 1.02g/ec and is less than that of other fishes which show 1.08 g/cc. When the cod or Alaska pollack is frozen, the meat becomes spongy because of the presence of bubbles from the air or other gases. In order to prevent its becoming "spongy", the meat should be cut into small cubes and air bubbles in the meat should be cut into small cubes and air bubbles in the meat should be removed in a vacuum chamber before freezing.

7. Discoloration(23) of squid or octopus

When squid or octopus is frozen, the former becomes red, and the latter becomes dark red. The meat of both kinds become red when boiled.

There are many pigment cells between the surface skin (epidermis) and the true skin (corium); pigment is still dark red brown during the condition of rigor mortis after being caught. The pigment cells are enveloped by an elastic membrane. The pigment is melanine. If the membrane is shut, the pigment cells become invisible from the upper side of the squid. If the membrane is open, the pigment cells exhibit a dark red or brown color. That is to say, when the squid is fresh, the surface appears dark red or brown but as staleness developes, the pigment is dissolved by the alkaline reaction of the meat, becoming red. When squid is frozen, the membrane of the cell is destroyed, and with a rise of the storage temperature the pigment flows out on the surface of the squid to become red in color. In order to prevent discoloration the cold storage temperature of frozen squid should be kept low at all times.

8. Brown or black spots of prawn

There often appear brown or black spots on the surface of joint meats of frozen prawn. This discoloration is attributed to the fact that tyrosin and similar substances which are contained in the liver of prawn are oxidized by tyrosinase in blood in the presence of oxygen to become melanine.(24)(25) This reaction is called melanosis. This is clearly an enzymatic discoloration. It is found also in fresh prawn meat. In frozen prawn the discoloration is accelerated by haemolysis and enzymatic action.

In order to prevent the discoloration, if it is possible, the head of the prawn to which the liver is connected, and tail should be cut off and the body washed to remove blood before freezing. If a water-soluble anti-oxidant, e.g. ascorbic acid, is properly used, the meat does not discolor. But when ascorbic acid is used in excess, the meat becomes white, and takes on an undesirable appearance.

When frozen prawn is exported, care should be taken about the content of *E. coli*. In order to prevent contanimation by the bacteria, care should be exercised in the treatment of the prawn.

9. Black spot and spongy meat of frozen crab meat

In frozen crab meat, black spot or spongy meat are often seen. The black spot of frozen crab meat is often found in meat previously subjected to the "low temperature boiling method"(26). This is also considered to be the cause of black spot in frozen prawn. Frozen crab meat subjected to the "high temperature boiling method" often has blue meat. It is caused by the oxidation of haemocyanine by oxidase in crab blood.

"Spongy meat" is due to the denaturation(27) of crab meat protein by freezing and is characterized by excessive drip upon thawing.

If the "low temperature boiling method" is employed, the crab blood will be removed and the formation of blue meat will be prevented.

10. Sanitary problems of "Short necked clams" and "hard clams"

Frozen short necked clams and hard clams are exported to the U.S.A. At the export inspection, the number of *E. coli* must be less than 2,400 per 100 cc in order to be acceptable. In order to avoid contamination, the treatment of these shell fish should be rigorously carried on.

11. Excessive drip in frozen oysters

Frozen oysters are also exported to the U.S.A. When frozen oysters are thawed the body fluid often flows out as drip. This is due to the chemical properties of oyster body meat, e.g. hydration ability of the meat protein. In order to prevent the excessive drip, the oyster meat upon removal from the shell is "brined" in 1% pure NaCl solution and, after brining, it should be frozen immediately at low temperature.

The contamination of oysters by *E. coli* is troublesome in Japan. The number of *E. coli* in oyster meat must be less than 230 per 100 cc. The treatment and handling of oysters should be sanitarily carried on in order to prevent contamination.

12. Prevention of spoilage of brine in Ottesen's freezing system

In Ottesen's freezing system, if the brine is left unused for a long time at room temperature, spoilage occurs and it becomes unfit for further use. In order to prevent such spoilage, care must be taken to keep the brine and some preservative method.(28) The spoilage of the brine is affected by the amounts of brine-soluble nitrogen contained therein, and by the temperature of the brine. Therefore, if the brine contained much brine-soluble nitrogen, and if it is left at comparatively high temperature, the brine begins rapid spoilage. In this case, the level for the spoilage of the brine is 100 mg% of the brine-soluble nitrogen. When the amount of volatile basic nitrogen becomes 20 mg%, the brine shows an appearance of incipient putrefaction. If the amount of volatile basic nitrogen becomes 30 mg%, the brine shows obviously spoil organoleptically. From the stage of 30 mg% of volatile basic nitrogen the pH values moves toward the alkalin side. The microflora in spoiled brine consists of mainly micrococci, and nitrofrazone is effective to inhibit the growth of the bacteria. Adding 5 ppm of nitrofrazone into the brine may inhibit the spoilage in spite of increase of the amount of brine-soluble nitrogen from raw fish and of higher temperature.

13. **Odorous components in refrigerating warehouse**

There are some components in the odors in the atmosphere of a refrigerating warehouse, which sometimes subject to damage the raw material stored there by absorbing the odors. These odors may be similar components in the refrigerating warehouse. Odors produced from raw material stored, and those resulting from a combination of these two. Odorous components in a refrigerating warehouse in which salmon is stored consists of basic, neutral and acid substances. The components detected in the refrigerating warehouse are piperidine, trimethylamine, formic acid, δ-aminovalerianic aldehyde, formaldehyde, mercaptan, ammonia, ethylene, hydrogen sulfide. Within these components, it appears that piperidine, trimethylamine, formic acid, δ-aminovalerianic aldehyde are evolved from salmon which is stored in the warehouse. While, there are ammonia, ethylene, formaldehyde and acetaldehyde in empty refrigerating warehouses. Thus the odorous components in a refrigerating warehouse in which salmon is stored are the mixture of the compositions produced from salmon and the particular odor of the warehouse which consists of the industrial gases.(29)

14. Cold storage of cod fillets

From studies on the cold storage of fish, it has been said that muscle must be frozen and stored at as low a temperature as possible. There is much need for a determination of the freezing conditions for manufacturing all frozen-dehydrated foods. According to studies by Love(30)(31)(32), and Love and Karsti(33) on freezing cod, even if the fish is frozen rapidly the flesh is damaged under certain conditions. According to Connell(34), if cod is frozen at -80°C and is dehydrated, a very fine porous structure is observed in the muscle fibre and water-retention is less than in cod flesh frozen at higher temperatures. Migita and Otake(35) observed that adenosine triphosphate added to the muscle of exhausted cod that died during struggling changes the chemical properties of the muscle protein to that of the muscle of fish killed instantly. Migita observed that polyphosphates has a similar effect. Tanikawa, Akiba and Shitamori(36) have studied how pretreatment with polyphosphate before freezing affects the chemical and histological properties of frozen cod tissue. Such treatment helps maintain good quality. For example, drip formation is less in cod tissue pretreated with polyphosphates. From histological observations and estimations of DNAP, during cold storage of frozen cod fillets, not only does flesh protein become insoluble in the initial period, but other changes occur in its properties, resulting in decreased drip and increased reabsorption ability. In cod tissue rapidly frozen at -90°C, some histological stabilization (e.g., forming of a network construction) is accompanied by the formation of ice crystals.

15. Effects of freshness of Alaska pollack on the quality of frozen product

Recent expansion of the North Pacific trawl fishery results in an abundant catch of Alaska pollack which is principal species for making fish paste ("Kamaboko"). Tanaka *et al.* have studied a series of the investigation on the effects of the freshness of the Alaska pollack prior to freezing and cold storage condition on the quality of the frozen fish flesh, examining from the aspects of histology, protein chemistry and "Kamaboko"-forming ability. With respect to the histological observation, Tanaka[37] obtained following results.

The size and distribution of ice crystals formed in the muscle were related to the freshness of the fish prior to freezing. It was observed that the formation of intracellular ice crystals of large size in the case of Group I (fish in *pre rigor*) and Group II (fish in early stage of *rigor mortis*), and extracellular ice crystals formation in Group IV (*post rigor* fish). Group III (fish in late stage of *rigor mortis*) showed medium or mixed appearance of intra- and extra-cellular ice crystals formation. No difference in the formation and distribution of ice crystals in muscle was observed between the fish caught during June and September.

The muscle of the fish in Group III and IV, which had been stored for a short period, 1.5 to 3 months, when examined after thawing, was microscopically observed to be better than that of the fish in Group I, in which these were small spaces in cells. After 8 months of storage, the muscle of all fishes were not in good condition.

In general, the amount of free drip released during the thawing was at low level for all samples of the frozen fish, although the fish in Group IV showed a tendency to release comparatively larger amount of drip. In all cases, Group I to III, the amounts of expressible drip increased with length of storage time and the water holding capacity decreased. It is noteworthy that the muscle of fish caught in June showed a tendency to release larger amount of drip including free and expressible drip, and to have lower water holding capacity as compared with the muscle of fish caught in September.

The quality of frozen fish in Group I and II, even though the freshness prior to freezing was considered to be very good, was not always favorable, evaluating from the stand points of the drip loss, water holding capacity and the microscopical observation of muscle after thawing.

As to biological condition of fish, *i.e.* sex, size of fish appearance of skin color and spawning, it was found that the spawning affected greatly on the quality of frozen fish.

Umemoto and Kanna[38] have studied changes in muscle protein of the fish during cold storage at -20°C and -30°C for 1 to 8 months, and obtained results as follows.

Protein extractability of the frozen muscle with 0.6M KCl was fairly high (45～82% of total-N), and peaks of actomyosin were observed in ultracentrifugal analyses of the muscle protein extracts, and though faintly, some extracts exhibited flow birefringence. These results indicate that the protein denaturation is not so much even after long period of cold storage.

No definite relationship was observed between freshness of fish before freezing and muscle protein denaturation during cold storage. The muscle protein extracts with 0.6M KCl contained gel fraction protein (10～25% of extractable protein) which were sedimented by centrifugation at 20,000×G.

Okada and Iwata(39) have investigated changes in the "Kamaboko" forming capability during cold storage of Alaska pollack. For fish frozen for periods of 1 to 1.5 months storage at -20°C, those frozen *pre rigor* indicated a much higher "Kamaboko" forming capability than those frozen *in rigor* or *post rigor*. No distinct differences in the capability however found among the fishes frozen at various stages of post mortem after 2 or 3 months of cold storage. The fish caught in September had higher "Kamaboko" forming capability as well as more extractable meat protein, than those caught in June. This difference may be associated with the spawning of the fish which is presumed to occur in June.

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CANNED MARINE PRODUCTS

I. Development of the Canning Industry in Japan

According to the record, Japan acquired the art of canning from both France and the U.S.A. between 1870 and 1875. The French method was introduced into this country for the first time in the second year of the Meiji Era, 1869, when an experiment in canning (canned sardine in oil) was undertaken by Masanori Matsuda in Nagasaki Prefecture under the instruction of a French technician, M. Jullie, a teacher in the Ko-un Kwan school. This was about 60 years after the invention by M. Nicolas Appert of the food preserving methods which have developed into the modern canning industry.

In those days, people in this country showed no interest in canning either as producers or consumers. This was due no doubt to the unsettled social cond itions immediately following the Imperial Restoration("Ishin"). However, officials of the Government, who returned from inspection tours in Europe and America, attempted with great enthusiasm to establish various new industries on a modern basis, evidently believing that industrial developement was the first requisite for augmenting national wealth and power. Thus, a remarkable impetus was given to the initiation of different branches of modern industry.

In 1875, the Department of Home Affairs conducted its first experiments in food preservation at the Shinjuku Branch of its Industrial Board. By this time, Sakichi Yanagisawa, who had studied the art in the U.S. A., had returned to Japan and was invited by the Government department to demonstrate his skill in connection with canning peaches. Meanwhile, Meisei Sekizawa, who had acquired experience in the salmon canneries along the Columbia River in the U.S.A., came back from Vienna, where he had represented Japan at the International Exhibition of that year. He was so eager to promote the industry upon his return that he seized the first opportunity to obtain the hearing of Toshimichi Okubo, then

Minister for Home Affairs, to whom he reported upon the economic advantages that would be derived from the early establishment of canning factories. Acting upon his suggestion, an experimental station was built near the mouth of the Ishikari River in Hokkaido, to which instructors were invited from the U.S.A.

Despite all these attempts, however, no appreciable progress was made in the canning industry during the following ten or fifteen years.

A phenomenal change took place in the situation with the outbreak of the Sino-Japanese War in 1894. The Japanese Army began to use canned products then, and, as a result, a remarkable expansion was achieved in the canning industry in this country, the total production of canned food for that year reaching some 150, 000 cases. After the conclusion of the war, a large number of canners appeared in rapid succession, and the industry suffered from acute depression due to over production. But this setback only served to urge experimenter and manufacturer alike to greater effort. More varieties of canned foods, produced purely under a Japanese process, came upon the market. About this time a number of fishery laboratories made their appearance; the Imperial Fisheries Institute (at present, the University of Fisheries of Tokyo) was founded in 1897. Local schools for the scientific study of fishery and marine products and for instruction and training in all phases of this branch of learning have been opened since 1899. With the establishment of these Government institutions for scientific research, the number of factories and workers increased; and with better organisation and equipment, a fundamental change was effected in the industry as a whole.

Another favourable development was witnessed since 1904 in the canning industry in this country, when the Russo-Japanese War broke out. At that time, the military authorities adoped a policy of encouraging national self-sufficiency in foodstuffs. They afforded positive encouragement and assistance to canning enterprises, purchasing enormous amounts of canned products for army consumption. This action on the part of the military authorities contributed to an amazing degree toward development of the industry. It was from that time that seasoned sardine, striped tuna, mackerel, yellowtail and salmon came to be packed in tins. Remarkable progress has also been made in canning technique since then. In fact, later expansion in the field of exports may be attributable to the technical progress and experience acquired in those days.

It may also be said that the expansion of the salmon and crab canning industries in this country is partly ascribable to the rapid extension of canning enterprises after the acquisition of new fishing concessions in the Kamchatka Province and Maritime Province of Eastern Siberia (under the Russo Japanese Fishery Pact concluded after the Russo-Japanese War).

Table 4-1 shows the development in the production of canned foods during the 12 year period 1894-1905, which latter year saw the termination of the war with Russia.

Table 4-1. Annual production of canned foods in Japan from 1894 to 1905 (real no. of cases)

Year	Quantity (cases)	Year	Quantity (cases)
1894	204,062	1900	125,789
1895	105,220	1901	214,097
1896	51,686	1902	235,816
1897	71,207	1903	318,970
1898	75,360	1904	429,350
1899	89,325	1905	800,830

Table 4-2. Exports of canned foods from Japan from 1902 to 1911 (real no. of cases)

Year	Quantity (cases)	Year	Quantity (cases)
1902	11,786	1907	51,513
1903	11,751	1908	67,681
1904	12,296	1909	104,104
1905	68,875	1910	148,642
1906	61,174	1911	182,861

Technical improvements, better factory equipment and systematic eform in the methods of obtaining raw materials which war conditions had brought about, prepared the industry for the coming period of expansion and gave it sufficient strength to attempt competition in world markets.

Table 4-2 will give a general idea of the development of the Japanese export trade in canned foods during the period 1902-1911.

The shipments consisted mainly of marine products such as salmon and crab. As for the raw materials used for canning, the attention of Japanese canners was originally directed to the sardine, then to salmon and crab.

The production of canned food in Japan from 1912 to 1930 is shown in Table 4-3.

Table 4-3. Production and exports of canned foods in Japan from 1912 to 1930
(real no. of cases)

Year	Production	Exports
	Quantity (cases)	Quantity (cases)
1912	1,217	252
1913	1,065	275
1914	1,056	290
1915	1,006	355
1916	1,347	444
1917	1,633	476
1918	1,356	501
1919	1,800	325
1920	1,482	255
1921	1,737	417
1922	2,116	615
1923	2,392	415
1924	3,105	654
1925	3,609	1,028
1926	3,722	1,333
1927	3,510	1,280
1928	4,269	1,783
1929	4,397	1,746
1930	4,937	1,759

The quantities of different canned stuffs manufactured in Japan in 1930-1938, divided into major classes, are shown in Table 4-4.

Information on the quantities of canned stuffs manufactured in 1939-1947 are difficult to obtain, because of war time conditions. The quantities of different canned foods manufactured in Japan in 1948-1958, are shown in Table 4-5.

Table 4-4. Annual production of various canned foods
classified (1930-1938) (real no. of cases)

Year	Marine products (cases)	Vegetables (cases)	Fruits (cases)	Meat & Dairy (cases)	Total (cases)
1930	2,779,266	820,640	551,794	776,742	4,937,443
1931	2,137,111	491,914	966,503	773,289	4,268,817
1932	2,664,401	651,505	1,102,348	817,885	5,236,139
1933	3,389,087	552,372	1,467,615	891,640	6,300,714
1934	4,297,113	756,748	1,733,653	1,038,229	7,825,843
1935	4,921,113	772,813	1,841,166	1,136,349	8,672,196
1936	5,486,160	1,129,996	2,511,785	1,064,613	10,192,553
1937	7,735,009	1,298,168	2,879,401	1,246,401	13,158,988
1938	6,680,613	2,153,917	4,586,453	1,770,321	15,191,304

Table 4-5. Production of various canned foods (1)
(1948-1958) (real no. of cases)

Year	Marine Products (cases)	Vegetables (cases)	Fruits (cases)	Meat (cases)	Total (cases)
1948	426,688	90,968	213,236	9,617	740,509
1949	1,147,418	154,526	155,318	25,513	1,482,775
1950	3,529,846	330,505	1,329,854	314,900	5,504,452
1951	3,268,258	347,273	1,253,854	235,996	5,105,452
1952	4,173,713	370,526	1,336,014	284,033	6,164,286
1953	5,917,161	518,564	1,480,854	330,934	8,247,513
1954	8,041,859	437,920	3,119,442	486,956	12,086,177
1955	9,946,388	546,971	5,545,537	604,591	16,643,487
1956	13,117,737	758,042	6,711,603	796,963	21,384,345
1957	15,987,536	1,186,319	7,112,619	827,918	26,114,392
1958	17,852,404	1,638,707	9,556,622	953,191	30,000,924

As indicated in the fore-going tables, marine products head the list. In consideration of Japan's geographic position, it is but natural that this should be so. Moreover, marine products were the first to be put up by the canning industry. Next importance comes fruit. Among

Production of various canned foods (2) (1959-1962)
(real no. of cases) (unit: 1,000 cases)

Year	Marine Products (cases)	Vegetables (cases)	Fruits (cases)	Juices (cases)	Jams (cases)	Meat (cases)	Total (cases)
1959	21, 993	1, 780	10, 053	2, 263	663	1, 208	37, 960
1960	23, 676	2, 946	13, 963	4, 202	876	1, 561	47, 223
1961	26, 944	3, 296	13, 822	4, 919	922	1, 623	51, 526
1962	25, 334	2, 403	14, 215	4, 369	467	1, 383	48, 171

Table 4-6. Exports of various canned foods
(1930-1938) (real no. of cases)

Year	Marine Products (cases)	Vegetables (cases)	Fruits (cases)	Meat & Dairy (cases)	Total (cases)
1930	1, 657, 342	45, 338	37, 318	19, 248	1, 759, 246
1931	1, 307, 097	38, 906	51, 822	49, 457	1, 447, 282
1932	1, 939, 301	62, 103	81, 450	55, 903	2, 138, 757
1933	2, 821, 076	79, 736	238, 571	69, 709	3, 209, 092
1934	2, 914, 901	95, 179	408, 064	143, 692	3, 561, 808
1935	3, 158, 915	133, 676	375, 139	224, 749	3, 892, 479
1936	3, 949, 725	136, 639	1, 044, 482	179, 069	5, 309, 915
1937	5, 103, 998	214, 137	1, 281, 770	115, 811	6, 715, 716
1938	4, 699, 222	340, 077	1, 761, 157	356, 763	7, 157, 219

Table 4-7. Exports of various canned foods (1)
(1948-1958) (real no. of cases)

Year	Marine Products (cases)	Vegetables (cases)	Fruits (cases)	Meat (cases)	Total (cases)
1948	136, 168	38, 361	57, 887	—	232, 416
1949	561, 852	53, 101	54, 079	580	725, 798
1950	1, 935, 985	75, 910	102, 940	2, 945	2, 117, 780
1951	1, 354, 784	47, 514	344, 774	2, 859	1, 749, 931
1952	2, 100, 729	65, 547	432, 884	3, 491	2, 602, 651
1953	2, 788, 554	98, 368	303, 240	3, 389	3, 193, 551
1954	3, 785, 686	74, 742	1, 283, 359	3, 536	5, 147, 323
1955	4, 399, 324	66, 337	2, 654, 005	3, 300	7, 111, 966
1956	7, 136, 332	71, 851	2, 828, 300	5, 603	10, 043, 785
1957	7, 461, 481	84, 302	3, 038, 970	5, 603	10, 592, 587
1958	9, 198, 000	88, 095	3, 232, 690	4, 270	12, 523, 579

canned fruits, canned mandarian oranges take the lead in quantity of production. The canning of meat and dairy products is rather insignificant by comparison with the production in European or American countries. Natural conditions in Japan do not favour large-scale raising of cattle.

The annual exports of various canned foods, in 1930-1938, and 1948-1958 are shown in Tables 4-6 and 4-7.

Exports of various canned foods (2)
(1964-1969) (real no. of cases) (unit: 1,000 cases)

Year	Marine Products	Vegetables	Fruits	Meat	Jam	Juice	Total
1964	11,359	239	4,528	5	0	346	16,480
1965	10,410	235	4,822	7	1	400	15,878
1966	12,776	274	4,721	10	2	403	18,160
1967	13,893	334	7,114	7	5	559	21,914
1968	16,100	374	6,353	8	3	574	23,413
1969	16,474	256	6,451	10	7	879	24,080

The important kinds of canned marine products for export in 1968 are shown in Table 4-8.

Table 4-8. The important kinds of various canned marine products for export (1968)

Kinds of canned foods	Real number of cases	Converted number of cases (48 lb)
Crabs	328,267	136,443
Salmons	1,023,080	1,000,263
Tunas	7,121,483	2,968,711
Mackerel	6,627,313	5,069,356
Sardine	11,455	10,455
Saury	49,242	18,691
Pompanos ("Aji")	15,708	13,558
Shrimp	52,465	12,417
Squid	146,287	81,404
Other fishes	9,656	4,721
Shellfish	1,032,857	442,362
Processed marine products	56,642	27,688
Others	—	—
Total	16,474,455	9,786,051

As seen in Table 4-8, salmon, tunas, mackerel are the most important canned fish. Although the amounts of canned crab for export is smaller than those of canned tunas, salmon, and mackerel, the canned product is important because the price of it is expensive. Among canned shellfish, canned oyster and baby clam is important.

For the year 1968, the important kinds of canned marine products and their quantities are shown in Table 4-9. In this Table, "converted numbers" of cases are calculated as follows: The total number of cases of canned crab is converted into the number of cases of 4 dozen (1 lb can).

Table 4-9. Production of various canned marine products (1968)

Kinds of canned foods	Real number of cases	Converted number of cases
Crabs	1,091,105	326,444
Salmon	1,986,011	814,449
Tunas	6,238,990	2,634,177
Mackerel	12,706,205	7,663,256
Sardine	145,984	54,386
Saury	1,517,792	507,792
Pompanos ("Aji")	340,222	232,766
Whale	1,614,271	760,551
Squid	723,265	306,530
Other fish	704,950	217,977
Shellfish	3,217,366	915,297
Processed marine products	457,239	236,154
Total	30,743,400	14,705,781

As seen in Table 4-9, among canned marine products, the important foods are crab, salmon, tuna and bonito (skipjack), mackerel, sardine, saury, whale meat, squid, and shellfish. Among canned shellfish "Akagai" (a kind of arkshell) production is the highest.

II. Districts and Seasons of Production of the Important Kinds of Canned Marine Products

The districts producing the important kinds of canned marine products in Japan are the following prefecture as shown in Table 4-10.

Table 4-10. Principal districts and seasons of production of principal canned marine products

Kind of canned products	Production prefectures	Heavy production season
King crab	Okhotsk Sea, Hokkaido	April～Aug.
Horse-hair crab	Hokkaido	April～May
Salmon	Northern Pacific Ocean, Hokkaido	June～Aug.
Mackerel	Hokkaido, Aomori, Niigata,	autumn
	Shizuoka, Mie, Kyoto,	〃
	Shimane, Kumamoto,	〃
	Miyagi, Fukushima,	spring
	Ibaragi, Chiba, Toyama,	〃
	Niigata, Mie, Nagasaki	〃
Saury	Hokkaido, Iwate, Miyagi	Sept.～Oct.
	Chiba, Kanagawa	Oct.～Nov.
	Mie, Wakayama	June
Tuna	Iwate, Miyagi, Kyoto,	Summer
	Hiroshima, Chiba, Kanagawa	〃
	Mie, Kumamoto, Kochi	winter
	Tokushima	a whole year
Squid	Hokkaido, Aomori, Iwate	Aug.～Oct.
	Miyagi	Nov.～Dec.
	Kanagawa	Sept.
	Nagasaki	Nov.～Dec. Jan.～March
Cod	Hokkaido	April
Bonito	Iwate, Miyagi, Shizuoka	Aug.～Sept.
	Ibaragi, Chiba	June～Aug.
	Kanagawa, Mie, Wakayama	April～June
	Hiroshima	Sept.～Nov.
	Kumamoto	March～May
Sardine	Hokkaido, Aomori, Shizuoka, Mie	Aug.～Oct.
	Iwate, Fukushima, Ibaragi, Nagasaki	Nov.～Dec.
	Kanagawa, Kumamoto	Oct.～Nov.
	Chiba, Toyama, Shizuoka, Kyoto, Hiroshima	March～May
	Shimane	June～July

Kind of canned products	Production prefectures	Heavy production season
Sardine	Ibaragi, Mie, Yamaguchi, Nagasaki	Jan.～Feb.
Yellow-tail	Fukui	June～July
	Mie	Feb.～March
Scallop	Hokkaido	July～Aug.
Abalone	Hokkaido, Iwate, Miyagi	Oct.～Dec.
Oyster	Iwate, Miyagi	Feb.～April
	Hiroshima	March
Baby clam	Fukuoka, Kumamoto, Saga	April～Sept.

III. Classification of the Principal Canned Marine Products

The principal canned marine products in Japan are as outlined in Table 4-9. These canned foods may be classified into the following types according to the process.

Boiled;	Salmon, mackerel, sardine saury, cod, squid, oyster, abalone, top shell, hen clam, scallop, "akagai", short necked clam (baby clam), hard clam, crab, prawn (shrimp).
In Brine:	Tuna, bonito.
In oil:	Tuna, bonito, oyster (smoked).
In tomato sauce:	Mackerel, sardine, saury, pompanos, squid, whale meat, oyster, abalone, top shell, scallop, ligament, "akagai"
Seasoned;	Tuna flake, bonito flake, mackerel, sardine, saury, pompanos, squid, whale meat, oyster, abalone, top shell, scallop, "akagai", "asari" (short necked or baby clam), hard clam, eel, yellowtail, sea breams, squid, octopus, seaweeds, "konbu" (laminaria), fish ball, fish paste, etc.

Among the above marine products, seasoned canned foods are sold for domestic consumption. The greater part of the others are exported.

IV. Shape and Size of Cans

The automatic can making machine, that revolutionized the whole canning industry, was adopted by a Japanese cannery in 1914 in Kamchatka. In 1915, the packing company removed their automatic can-making machinery from Kamchatka to Hakodate and there specialized in the manufacture of metal containers not only for their own use but for the use of other companies in the business. This is the origin of the Hokkai Can Co. In 1917, the Toyo Can Co. was established in Osaka. Since then, the packers have devoted themselves to the processing of canned foods only. After some can-making enterprises were established, to meet the demand of packers, various shapes and sizes of metal containers have been manufactured. Because of the troublesomness of many shapes and sizes of metal containers, standarization of can sizes was discussed under the auspices of Japanese Canners' Association from 1930 to 1935, and standards were established. Since then some changes have been made. The following standards Table 4-11 are now in force in Japan.

Table 4-11. Japanese Canners' Association's standard can size

Name of cans	Given name of diameter (in inches)	Standard size by Japanese Canners' Ass.		Inner volume (cc)
		diameter (mm)	height (mm)	
No. 1 can	603	156.00	169.62 168.00	2,974.6
Special No. 1 can	603	156.00	177.40	3,090.5
No. 2 can	401	101.50	121.00	872.3
No. 3 can	307	86.50	113.50	572.7
No. 4 can	301	77.00	113.50	454.4
No. 5 can	301	77.00	81.50	318.7
No. 6 can	301	77.00	59.30	223.2
No. 7 can	211	68.00	101.30	318.2
Special No. 7 can	211	68.00	76.20	231.2
No. 8 can	211	68.00	53.00	152.5
Flat No. 1 can	401	101.50	68.00	468.2
Flat No. 2 can	307	86.50	53.00	247.2

Name of cans	Given name of diameter (in inches)	Standard size by Japanese Canners' Ass.		Inner volume (cc)
		diameter (mm)	height (mm)	
Flat No. 3 can	301	77.00	36.50	125.9
Salmon Flat No. 2 can	307	86.50	51.33	240.5
Salmon No. 4 can	301	77.00	119.00	479.6
Salmon 2 kg can	603	156.00	109.30	950.0
Crab No. 1 can	401	101.50	71.50	493.7
Crab No. 2 can	307	86.50	56.00	265.2
Crab No. 3 can	301	77.00	39.50	138.6
Large Oval can		193.00 ×113.00	42.00	
Oval No. 1 can		102.00 ×110.5	38.50	448.2
Oval No. 3 can		128.50 × 86.00	32.00	225.2
Tuna No. 1 can	401	101.50	59.30	396.6
Tuna No. 2 can	307	86.50	46.50	208.9
Tuna No. 3 can	211	68.00	39.50	108.9
Tuna 1 kg can	603	156.00		950.0
Tuna 2 kg can	603	156.00	112.59	1,959.1
Tuna 2.5 kg can	603	156.00	126.50	2,203.9
Tuna 5 kg can	813	222.50		4,124.0
Tuna 1/2 kg can	401	101.50		315.0
Tuna 1/4 kg can	307	86.50		175.0
Tuna 1/8 kg can	211	68.00		
Square can No. 3B				120.9
Square can No. 3C		108.00 × 78.50	18.00	84.0
Square can No. 3D 3/4		108.00 × 78.50	52.00	223.0
Square can No. 3E		108.00 × 78.50	29.00	173.7
Square can No. 5A		107.00 × 63.00	30.00	135.0
Square can No. 5B		107.00 × 63.00	25.00	
Square can No. 5C		107.00 × 63.00	19.00	71.7
Square can No. 7A		100.00 × 48.00	30.00	(roll off) 69.9 (total)97.7
Square can No. 7B		100.00 × 48.00	24.00	

Name of cans	Given name of diameter (in inches)	Standard size by Japanese Canners' Ass.		Inner volume (cc)
		diameter (mm)	height (mm)	
Square can No. 7C		100.00 × 48.00	20.00	61.0
Square can No. 8				233.2
Square can No. 9				282.8

V. Marks on the Cover of Canned Foods

On the surface of covers of canned foods, there are three lines of letters, for example as shown in Fig. 4-1. These letters are called can marks.

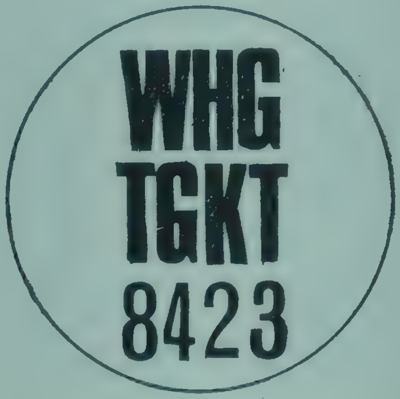

Fig. 4-1. Can marks

In Fig. 4-1, the first line shows the kind of product. The first two letters of the first line show the kind of raw material used. The third letter shows the kind of processing. (e.g., boiled, seasoned, or in oil). The second line shows the names of the packers and their factories, i.e. the first three letters show the name of the canning company and the fourth letter stands for the name of the factory in which the can was packed. The third line shows the date of production. viz., the first figure shows the last figure of the year. e.g. 8 means 1958: the second figure shows the number of the month, e.g. 4 means April; the last one or two figures show the number of the day. Here, October is shown as 0, November is shown as Y, December is shown as Z.

Fig. 4-1, for example, shows that this can (seasoned whale meat) was packed at the Tokyo factory of Taiyo Gyogyo Kaisha (Taiyo Fishing Co.) on 23th of April in 1958.

The can marks are regulated by the Japanese Canners' Association. The can marks showing the kinds of raw marine products are listed in Table 4-12.

Table 4-12. Can marks according to raw materials and processing

“A”	
Abalone (boiled)	A B N
〃 (seasoned)	A B C
〃 cut (seasoned)	A B C.
Alaska pollack (boiled)	A A N
Albacore (in brine)	A C L
〃 (in oil) olive oil	A C O
〃 (〃) cotton seed oil	A C I
〃 (〃) soya bean oil	A C 2
〃 (〃) corn oil	A C 3
〃 (〃) mixed oil	A C 4
Albacore flake (in oil) olive oil	A C O.
〃 (〃) cotton seed oil	A C 1.
〃 (〃) soya bean oil	A C 2.
〃 (〃) corn oil	A C 3.
〃 (〃) mixed oil	A C 4.
Albacore (without brine)	A C W
〃 (seasoned)	A C C
Albacore flake (seasoned)	A C C.
Albacore (seasoned with vegetables)	A C C V
〃 (in cream)	A C H
〃 (in jelly)	A C G
Albacore belly meat (in oil) olive oil	A C O Y
〃 〃 (〃) cotton seed oil	A C 1 Y
〃 〃 (〃) soya bean oil	A C 2 Y
〃 〃 (〃) corn oil	A C 3 Y
〃 〃 (〃) mixed oil	A C 4 Y
Albacore meat paste	A C P A
“Hamo” (*Muranesox cinereus*) (seasoned)	A E K
“Ami” (*Neomysis japonica*) (seasoned)	A I A
“Ayu” (*Plecoglossus altivelis*) (seasoned)	A U C
“Anago” (*Astroconger myriaster*) (seasoned)	A G K
“B”	
“Tokobushi” (*Haliotis japonica*) (boiled)	B A N
〃 (〃) (seasoned)	B A C
〃 (〃) (skewered) (seasoned)	B A R K
〃 (〃) (with shell) (boiled)	B A N X

"Asari" (short necked clam) (boiled)	B C N
〃 (〃) (seasoned)	B C C
〃 (〃) (fried)	B C F
〃 (〃) (with shell) (boiled)	B C N X
Big eye tuna (in brine)	B E L
〃 (in oil) olive oil	B E O
〃 (〃) cotton seed oil	B E I
〃 (〃) soya bean oil	B E 2
〃 (〃) corn oil	B E 3
〃 (〃) mixed oil	B E 4
Big eye tuna flake (in oil) olive oil	B E O.
〃 〃 (〃) cotton seed oil	B E 1.
〃 〃 (〃) corn oil	B E 3.
〃 〃 (〃) mixed oil	B E 4.
Big eye tuna (without brine)	B E W
〃 (seasoned)	B E C
Big eye tuna flake (seasoned)	B E C
Big eye tuna (seasoned with vegetables)	B E C V
〃 (in cream)	B E H
〃 (in jelly)	B E G
Big eye tuna belly meat (in oil) olive oil	B E O Y
〃 〃 (〃) cotton seed oil	B E 1 Y
〃 〃 (〃) soya bean oil	B E 2 Y
〃 〃 (〃) corn oil	B E 3 Y
〃 〃 (〃) mixed oil	B E 4 Y
Big eye tuna meat paste	B E P A
"Bai" (*Babylonia japonica*) (seasoned)	B I C
"Akagai" (a kind of arkshell) (seasoned)	B L C
Blue fin tuna (in brine)	B T L
〃 (in oil) olive oil	B T O
〃 (〃) cotton seed oil	B T 1
〃 (〃) soya bean oil	B T 2
〃 (〃) corn oil	B T 3
〃 (〃) mixed oil	B T 4
Blue fin tuna flake (in oil) olive oil	B T O.
〃 〃 (〃) cotton seed oil	B T 1.
〃 〃 (〃) soya bean oil	B T 2.
〃 〃 (〃) corn oil	B T 3.
〃 〃 (〃) mixed oil	B Y 4.
Blue fin tuna (seasoned)	B T C
Blue fin tuna flake (seasoned)	B T C.
Blue fin tuna (without brine)	B T W

〃 (seasoned with vegetable)	BTCV
〃 (in cream)	BTH
〃 (in jelly)	BTG
Blue fin tuna belly (in oil) olive oil	BTOY
〃 〃 (〃) cotton seed oil	BT1Y
〃 〃 (〃) soya bean oil	BT2Y
〃 〃 (〃) corn oil	BT3Y
〃 〃 (〃) mixed oil	BT4Y
Blue fin tuna meat paste	BTPA
Blue fin tuna meat (broiled)	BTK

“C”

“Agemaki” (*Sinononvacula constricta*) (seasoned)	CCC
〃 (〃 〃) (broiled)	CCK
“Torigai” (a kind of cockle, heart clam) (boiled)	CDN
〃 (〃) (seasoned)	CDC
Squid (boiled)	CHC
〃 (seasoned)	CHN
Squid minced (boiled)	CHNN
〃 〃 (seasoned)	CHCN
Squid (broiled)	CHK
Cod (boiled)	CON
〃 (seasoned)	COC
Smoked cod (in oil)	COS
Salmon (boiled)	CSN
Smoked salmon (in oil)	CSS
Salmon (neck meat) (boiled)	CSNT
Squid (with viscera) (boiled)	CVN
Freshwater clam (boiled)	CJN

“E”

Eel (seasoned, “Yahata maki”)	EB
〃 (broiled and seasoned)	ELK
Anchovy (boiled)	ENN
〃 (in oil) olive oil	ENO
〃 (〃) cotton seed oil	EN1
〃 (〃) soya bean oil	EN2
〃 (〃) corn oil	EN3
〃 (〃) mixed oil	EN4
Anchovy (seasoned)	ENC
〃 (in tomato sauce)	ENT
〃 (skewered and roasted)	ENRK

“F”

Fish paste	F M

“H”

“Hanasaki”-crab	H C N
Herring (boiled)	H E N
〃 (in oil) olive oil	H E O
〃 (〃) cotton seed oil	H E 1
〃 (〃) soya bean oil	H E 2
〃 (〃) corn oil	H E 3
〃 (〃) mixed oil	H E 4
Smoked herring (in oil)	H E S
Kippered herring	H E S K
Herring (in red pepper)	H E 5
〃 (in mustard)	H E 6
〃 (in curry)	H E 7
〃 (in pepper)	H E 8
〃 (seasoned)	H E C
Atka mackerel (seasoned)	H K C
“Aji” (pompanos) (seasoned)	H M C
〃 (〃) (in tomato sauce)	H M T
〃 (〃) (sweetly seasoned)	H M C
Crucian carp (sweetly seasoned)	H N C
〃 (skewered and roasted)	H N R K
Hen clam (boiled)	H O N
〃 (minced) (boiled)	H O N N
Flat fish (fried)	H R F
Gobies (sweetly seasoned)	H 2 C

“J”

King crab (boiled)	J C N
〃 (boneless)	J C N A
Skipjack (cubic meat) (seasoned)	J K
Bonito fish powder	J M

“K”

“Kegani” (Horse hair-crab) (boiled)	K C N
“Kegani”-flake (boiled)	K C N.
King salmon (boiled)	K S N
King salmon (necked meat) (boiled)	K S N T

“L”

Whiting (*Salongichthys microdon*)	L A N
Fish liver paste	L I P A

“Taira-gai” ligament (boiled)	L R N
〃 〃 (seasoned)	L R C
Scallop ligament (boiled)	L S N
Larval fish (boiled)	L F N

“M”

Mackerel (boiled)	M K N
〃 (in oil) olive seed oil	M K O
〃 (〃) cotton seed oil	M K 1
〃 (〃) soya bean oil	M K 2
〃 (〃) corn oil	M K 3
〃 (〃) mixed oil	M K 4
〃 (in red pepper)	M K 5
〃 (in mustard)	M K 6
〃 (in curry)	M K 7
〃 (in pepper)	M K 8
Mackerel fillet (in oil) olive oil	M K O F
〃 〃 (〃) cotton seed oil	M K 1 F
〃 〃 (〃) soya bean oil	M K 2 F
〃 〃 (〃) corn oil	M K 3 F
〃 〃 (〃) mixed oil	M K 4 F
Mackerel (seasoned)	M K C
Mackerel flake (seasoned)	M R C.
Mackerel (Seasoned with vegetables)	M K C V
〃 (roasted)	M K K
〃 (seasoned with bamboo)	M K C B
Small mackerel (boiled)	M K N S
〃 〃 (in tomato sauce)	M K T S
〃 〃 (seasoned)	M K C S
Mackerel (in tomato sauce)	M K T
Saury (boiled)	M P N
Smoked saury (in oil)	M P S
Saury (in tomato sauce)	M P T
〃 (in red pepper)	M P 5
〃 (in mustard)	M P 6
〃 (in curry)	M P 7
〃 (in pepper)	M P 8
〃 (in other or mixed)	M P 9
〃 (seasoned)	M P C
〃 (roasted)	M P K
“Uba-gai” (seasoned)	M R C
“Igai” (blue mussel) (boiled)	M U N

“N”

“Nishi” (seasoned)	NLC

“O”

Octopus (boiled)	OCN
〃 (seasoned)	OCC
〃 (roasted)	OCK
〃 (skewered and roasted)	OCRK
Smoked octopus (in oil)	OCS
Cod roe (seasoned)	OOC
Mackerel roe (seasoned)	OKC
Oyster (boiled)	OYN
Smoked oyster (in oil)	OYS
Oyster (roasted)	OYK
Cod roe flake (seasoned)	OOC.

“P”

Small octopus (*Polapus hong king ensis*) (seasoned)	POC
Pink salmon (boiled)	PSN
〃 (necked meat) (boiled)	PSNT
〃 (seasoned)	PSC
Smoked pink salmon (in oil)	PSS
Pond smelt (boiled)	PTN
〃 (seasoned)	PTC
Spiny lobster (boiled)	PNN

“Q”

Shellfish meat soup	QC

“R”

“Mate-gai” (Jack knife clam) (boiled)	RAN
〃 (〃) (seasoned)	RAC
〃 (〃) (skewred and roasted)	PARK
Carp (boiled)	RPN
〃 (seasoned)	RPC
〃 (fried)	RPF
Red salmon (boiled)	RSN
〃 (necked meat) (boiled)	RSNT
Rainbow trout (boiled)	RTN
Smoked rainbow trout (in oil)	RTS

“S”

Sardine (boiled)	SAN
〃 (in oil) olive oil	SAO
〃 (〃) cotton seed oil	SA1

Sardine (in oil) soya bean oil	SA2
〃 (〃) corn oil	SA3
〃 (〃) mixed oil	SA4
〃 (in red pepper)	SA5
〃 (in mustard)	SA6
〃 (in curry)	SA7
〃 (in pepper)	SA8
Smoked sardine in oil	SAS
Sardine (seasoned)	SAC
〃 (seasoned with "miso")	SAB
〃 (roasted)	SAK
〃 (in tomato sauce)	SAT
"Zuai-gani" (boiled)	SCN
Round herring (*Etrumeus micropus*) (boiled)	SEN
〃 (〃) (in tomato sauce)	SET
〃 (〃) (seasoned)	SEC
Shark fin (boiled)	SFN
Shark fin soup	SFQ1
Bonito (boiled without salt)	SJW
〃 (in brine)	SJL
〃 (in oil) olive oil	SJO
〃 (〃) cotton seed oil	SJ1
〃 (〃) soya bean oil	SJ2
〃 (〃) corn oil	SJ3
〃 (〃) mixed oil	SJ4
Bonito flake (in oil) olive oil	SJO.
〃 〃 (〃) cotton seed oil	SJ1.
〃 〃 (〃) soya bean oil	SJ2.
〃 〃 (〃) corn oil	SJ3.
〃 〃 (〃) mixed oil	SJ4.
Bonito (seasoned)	SJC
Bonito flake (seasoned)	SJC.
Bonito (seasoned with bamboo shoot)	SJCB
Smoked bonito in oil	SJS
Bonito meat paste	SJPA
Bonito (broiled)	SJK
〃 (in jelly)	SJG
〃 (belly meat) (in oil) olive oil	SJOY
〃 (〃) (〃) cotton seed oil	SJ1Y
〃 (〃) (〃) soya bean oil	SJ2Y
〃 (〃) (〃) corn oil	SJ3Y
Salmon (seasoned with bamboo shoot)	SM

"Sujikatsuwo" (common bonito) (in brine)	SOL
〃 (in oil) olive oil	SOO
〃 (〃) cotton seed oil	SO1
〃 (〃) soya bean oil	SO2
〃 (〃) corn oil	SO3
〃 (〃) mixed oil	SO4
〃 (seasoned)	SOC
Scallop ligament (boiled)	SPN
〃 〃 (seasoned)	SPC
Shrimp (boiled)	SRN
〃 (dry pack)	SR
Smoked shrimp in oil	SRS
Sliver salmon (boiled)	SSN
〃 〃 (necked meat)	SSNT
Smoked silver salmon in oil	SSS
Sea urchin (roasted)	SD

"T"

Rolled laminaria (seasoned)	TA
"Tanago" (a species of minnow) (roasted)	TI
"Chikuwa" (a kind of fish paste)	TWR

"W"

Whale meat (connective tissue meat) (seasoned)	WHC
〃 (〃) (cut)	WHCC
〃 (〃) (seasoned with bamboo shoot)	WHCB
Sperm whale meat (seasoned)	WPC
〃 (seasoned with vegetables)	WPCV
Hard clam (boiled)	WLN
〃 (seasoned)	WLC
Smoked hard clam in oil	WLS
Top shell meat (seasoned)	WRC
〃 (skewered and roasted)	WRRK

"Y"

Yellow finned tuna (in brine)	YNL
〃 〃 〃 (boiled without salt)	YNW
〃 〃 〃 (in oil) olive oil	YWO
〃 〃 〃 (〃) cotton seed oil	YN1
〃 〃 〃 (〃) soya bean oil	YN2
〃 〃 〃 (〃) corn oil	YN3
〃 〃 〃 (〃) mixed oil	YN4

Yellow finned tuna flake meat (in oil) olive oil	YNO.
〃 〃 〃 〃 〃 (〃) cotton seed oil	YN1.
〃 〃 〃 〃 〃 (〃) soya bean oil	YN2.
〃 〃 〃 〃 〃 (〃) corn oil	YN3.
〃 〃 〃 〃 〃 (〃) mixed oil	YN4.
Yellow finned tuna (paste meat)	YNPA
〃 〃 〃 (belly meat) (in oil) olive oil	YNOX
〃 〃 〃 (〃) (〃) cotton seed oil	YN1Y
〃 〃 〃 (〃) (〃) soya bean oil	YN2Y
〃 〃 〃 (〃) (〃) corn oil	YN3Y
〃 〃 〃 (〃) (〃) mixed oil	YN4Y
Yellow finned tuna (seasoned)	YNC
Yellow finned tuna flake meat (seasoned)	YNC.
Yellow finned tuna (seasoned with vegetables)	YNCV
Yellow tail (in brine)	YTL
〃 (boiled without salt)	YTW
〃 (in oil) olive oil	YTO
〃 (〃) cotton seed oil	YT1
〃 (〃) soya bean oil	YT2
〃 (〃) corn oil	YT3
〃 (〃) mixed oil	YT4
Yellow tail flake meat (in oil) olive oil	YTO.
〃 〃 (〃) cotton seed oil	YT1.
〃 〃 (〃) soya bear oil	YT2.
〃 〃 (〃) corn oil	YT3.
〃 〃 (〃) mixed oil	YT4.
Smoked yellow tail in oil	YTS
Yellow tail (seasoned)	YTC
〃 (roasted)	YTK
Yellow tail meat paste	YTPA

SALMON CANNING

I. Salmon Fishing in Japan

1. History

The salmon fishing industry has existed in Japan since ancient times, but it is hardly necessary to say that, prior to the development of the canning industry, the fish caught by primitive methods were solely for distribution in either fresh or salted form. The fishing grounds were also restricted to the north-eastern districts of Honshu and Hokkaido.

Remarkable progress has been achieved in this particular line of the fishing industry in recent years, two important epochs in the history of the industry being attained as the result of the Sino-Japanese War of 1894-5 and the Russo-Japanese War of 1904-5. It is especially notable that, as a result of the conclusion of the Russo-Japanese Fishery Pact, there was a considerable increase in the number of Japanese fishermen operating in Russian waters after 1907. In 1910, a canning industry was established by Japanese in Kamchatka, and since then, striking developments have taken place in the salmon fishing industry in this region.

Until the year 1945, when the Soviet Union entered World War II against Japan, the Kamchatka province, Karafuto, Hokkaido and the Kurile Islands, which are washed by the Okhotsk and Bering Seas, were, the two really great salmon fishing banks of the world with the Pacific coast of North America.

As a result of World War II, Japan lost not only all her rights and interests in Kamchatka, but also the territories of Karafuto and the Kurile Islands. From 1945 to 1952 was a dark age. During that time, salmon fishing was carried on only in the waters surrounding Hokkaido.

In the year 1952, when peace was restored, salmon fishing was reopened on the high seas of the Okhotsk and Bering Seas. In the same year, the Japanese-American-Canadian Fishery Pact was concluded, by which Japanese salmon fishing was restricted to seas west of 175° west longitude. At that time the number of Japanese floating salmon canneries was three. Due to the success of salmon fishing in the high seas by drift nets, in 1956 the number of floating salmon canneries increased to 16.

From 1956 the Bulgarnin line (restricted fishing ground) and restricted amount of salmon catch were declared by the Soviet Union. The catch of mothership system in A area was restricted to 45 thousand tons in 1965, 48 thousand tons in 1966, 42 thousand tons in 1967, 37 thousand tons in 1968, and 49 thousand tons in 1969.

Thus, today, the Japanese salmon fishing is carried on in the restricted high seas of the Bering Sea (northern Pacific Ocean) by 11 mother ships in 1969.

2. Varieties of salmon and fishing grounds

The principal species of salmon used as material for canning purposes are the following: pink, chum, red, silver and king, but in Japan Proper, the first two kinds predominate, while very little of the other varieties are caught in this region. Red salmon are caught in abundance off the east and west coasts of Kamchatka, in the Bering Sea and in waters surrounding the Kurile Islands, whereas the catching of silver and king salmon is practically limited to the eastern coast of the same peninsula and to the Bering Sea. Particulars of the five principal species of salmon are as follows:

a. Red salmon ("beni-sake", *Onchorhynchus nerka*)

This variety is known as red salmon, sockeye salmon or blueback salmon on the Pacific coast of North America, and is considered the best for canning. Some amount of this variety is caught in the seas off the Kuriles, but there are big schools of them in the waters off the coast of Kamchatka or in Bering Sea. Practically 100% of the annual catch of this variety is canned.

b. King salmon ("masunosuke", *Onchorhynchus tschawytscha*)

This variety is known as king salmon, chinook salmon or spring salmon. It is caught off the eastern coast of Kamchatka and in the Bering Sea, but in small quantities. Salmon of this kind is either "mild cured" or canned.

c. Silver salmon ("gin-sake", *Onchorhynchus kisutch*)

In English-speaking countries, this is known as silver salmon, silverside, medium red or coho salmon. It is caught in the seas off Kamchatka and in the Bering Sea, although in small quantities.

d. Chum salmon ("shiro-sake, or sake", *Onchorhynchus keta*)

This variety is generally known as dog salmon, chum salmon or keta salmon. Of all the varieties of salmon, this kind is most abundant in the waters that wash the northern coasts of Japan Proper. The area for fishing this kind of salmon is very extensive, streching from the north-eastern part of Japan to Kamchatka. Chum salmon is largely salted, but it is used also as canned food.

e. Pink salmon ("karafuto-masu", *Onchorhynchus gorbuscha*)

This kind is known as pink salmon or humpback salmon. In Japan, this variety is caught off the Kulile Islands, Karafuto and in also the Bering Sea, while it is caught practically in every locality within the areas from Kamtchatka to the Okhotsk region. The annual production of canned pink salmon exceeds that of red salmon.

f. "Masu" (*Onchorhynchus masou*)

This variety is particular in Japan. It is caught off Hokkaido and Honshu. This is largely eaten as fresh fish, but has recently been used also as canned food to some small extent.

3. **Salmon catching**

The salmon industry depends to a great extent upon the spawning migration, for it is only at this time that salmon may be caught in quantity. Coming in from the open sea in immense schools to spawn, they fall an easy prey to various types of nets, traps, and even hook and line.

In general, salmon are taken either by "fixed gear" or "floating gear". The fixed gear includes traps, consisting of large stationary pound nets. The large sized "tate-ami", (a kind of fixed gear and similar in principle and construction to the American salmon trap), was popularly used, when salmon was canned in land canneries in Kamchatka under the Russo-Japanese Fishery Act prior to World War II.

The "floating gear" includes purse-seine boats, gill-net boats, trolling (hook and line) boats, and floating traps. In the northern Pacific Ocean including the Bering Sea, the drift net is resorted to in the case of the so-called "salmon fishing of mother-ship system". The "salmon fishing of the mother-ship system" is operated from a "mother-ship", which is

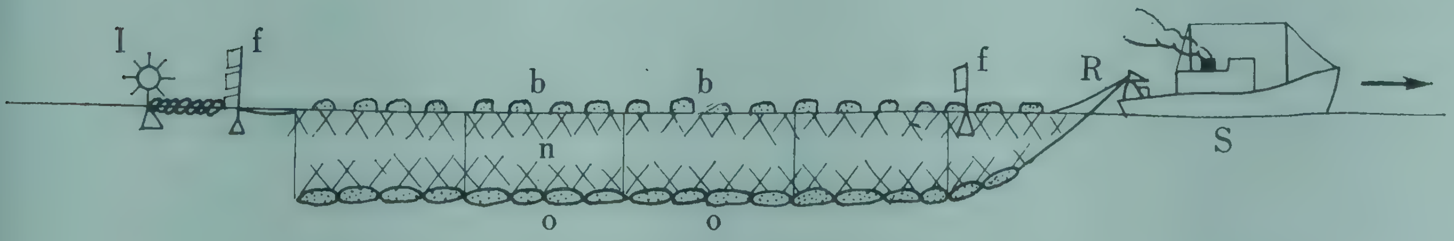

Fig. 4-2. Drift net

S—Fishing boat, R—Net roller, l—Sign light, f—Sign flag, b—Buoy rope, O—Foot rope, n—Net.

equipped with canning and other preserving facilities, or its auxiliary ships. Permission from the Minister of Agriculture and Forestry is necessary to operate in this manner, since such operation are controlled by Government Regulations.

The drift net is shown in Fig. 4-2.

II. Salmon Canning Industry in Japan

1. **History**

The origin of the salmon canning industry in Japan may be traced as far back as 1877, in which year an experimental station for canning was established in the province of Ishikari, Hokkaido, where American canning experts were employed to give Japanese the necessary instruction in canning processes. This experimental enterprise was followed in later years by 5 or 6 canneries erected at various places in Hokkaido.

These canneries supplied their products to the Imperial Navy, and while they exhibited samples of their canned salmon at expositions in foreign countries in an attempt to expand their markets, there was no appreciable progress visible in the industry until about the year 1890.

Epoch-making developments were occurred, however, at the time of the Sino-Japanese War of 1894-5 and the Russo-Japanese war of 1904-5, as there was a very considerable increase in the demand for canned salmon as provisions during the period of hostilities. Following the conclusion of the Russo-Japanese Fishery Convention in 1907, the number of Japanese fishermen showed a steady increase in Kamchatka and the Maritime Province ; finally Japanese owned canneries came to be erected in kamchatka in 1910. At first, these canneries were on a small scale, but in 1913, a set of American automatic canning machinery was installed in the cannery operated by Tsutsumi Shokai. Soon afterward the Nichiro Fishery Company, Limited, and the Export Food Products Company, Limited, adoped in succession similar automatic machinery for their plants. This marked a new epoch in the canning industry of Japan. Since then phenomenal developments have taken place in the salmon canning industry in Kamchatka as well as in Hokkaido and Aomori Prefectures. After World War II, the salmon canning has been carried on by floating canneries, since the year 1952.

2. Kinds of canned salmon

There are several kinds of canned salmon as follows: solid meat, canned salmon neck meat and canned seasoned salmon with or without bamboo shoots.

According to Japanese Government Regulations, canned salmon on solid meat or simply "canned salmon" is that prepared by using each species of salmon. After head, tail, fins and entrails are removed, the fish body is cut according to respective can heights and the cut fish meat pieces are packed in the can with an adequate amount of salt, after which the can is processed. These cans are exported, after having been inspected by the Japanese Canned Foods Inspection Association. Canned salmon neck meat is that neck meat (See Fig. 4-3) of each species of salmon which is processed in the same manner as canned salmon solid meat.

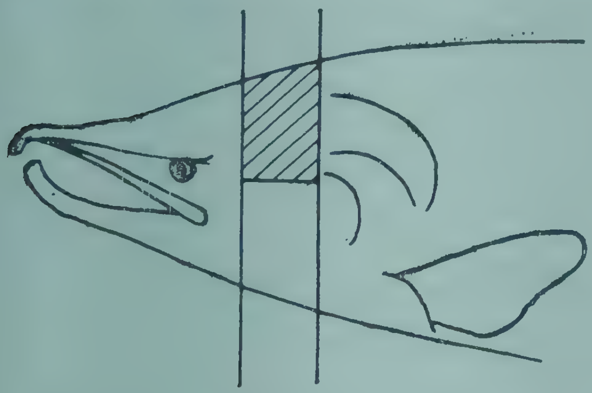
Fig. 4-3 Neck meat of salmon

These cans are also sometimes exported. Canned seasoned salmon solid meat seasoned with a sauce made from soy bean sauce ("shoyu") and sugar, and then processed. Canned seasoned salmon meat with bamboo shoots is the salmon solid meat seasoned with the same seasoning soy bean sauce as described above, filled in a can with cut and seasoned bamboo shoots and then processed. This canned seasoned salmon is for domestic use.

3. Production of canned salmon

Salmon is generally packed for canned boiled meat. In order to completely utilize the fish body, neck meat and other parts are also packed. Salmon is also utilized for canned smoked meat, canned seasoned meat with or without bamboo shoot, and canned meat in tomato sauce.

The total catch of salmon in 1968 was 126 thousand tons and the production of various kinds of canned salmon in this year is shown in Table 4-13.

Table 4-13. Production of canned salmon in 1968

Kind	Can size and no. of cans in a case	Real no. of cases	Converted no. of cases (48 one lb case)
Boiled salmon	Salmon flat 2/4 dozen	1,094,697	535,088
	〃 〃 3/4	619,148	151,320
	〃 〃 3/8	78,705	38,471
	〃 〃 2/2	161	152
	〃 〃 4/2	6,067	3,034
	Salmon 2 K/6 cans	26,001	13,144
Total		1,824,779	741,209
Salmon neck meat, or other boiled	Salmon flat 2/4 dozen	134,210	65,602
	〃 〃 3/4	21,715	5,307
	〃 〃 2/2	8	7
Total		155,933	70,916
Others	Salmon flat 2/4 dozen	4,061	2,121
	〃 〃 3/4	427	104
	Square 3 B/25 cans	811	90
Total		5,299	2,324
Sum grand		1,986,011	814,449

III. Salmon Packing

1. Procedures

Salmon, after being caught, are taken to a floating cannery in the fishing boats (auxiliary fishing boats to mother-ship). On arrival at the floating canneries, the fins and head of the fish are cut off and gutted by means of an "iron chink". An "iron chink" is a complicated machine equipped with a series of knives and brushes which rapidly remove the heads, fins, tails and entrails of the fish under jets of running water. King salmon are usually dressed and cleaned by hand.

The next stage is the sliming of the salmon; this means removing viscera by machine, a "slimer", or by hand any remaining blood, slime, loose membranes, etc. After careful washing in fresh water the dressed fish are carried to the "fish cutter", which cuts the fish into pieces in accordance with the size of cans to be filled. The pieces of fish are then packed into the cans by a "filler" which fills each can with the proper amount of fish meat; sufficient salt is also automatically added by a "salter" before placing fish pieces in cans.

The filled cans are then carried on belts to the "patching table", where they are either weighed automatically or inspected to see that they contain the proper amount of fish and have no bone or skin showing at the top; the cans were previously cleaned by steam or with clean water.

After passing through the "weighing machine", the cans are partially sealed by a "clincher", and then go directly to the "vacuum-closing machine" ("vacuum-double seamer"), by which the lids of the cans are tightened and sealed mechanically in a vacuum, without employing "exhaust box". The double seamers employed in Japan are of both old to new types. A recent new type of closing-machine, 802, 3V, Canco type closing machine, can close cans at the rate of 250 cans per minute.

The closed cans are rolled into the "cooler" or into large shallow trays, made of flat iron strips, each holding several dozen cans. Several of these "coolers" are cooked in a "retort" by steam under pressure. One-pound cans of salmon are usually cooked from 80 to 90 minutes at 240-245°F (116-118.5°C) (10-13 1b-presure). The 1/2-pound cans receive a treatments of about 70 to 75 minutes at the same temperature.

After processing, the cans are rolled out of the retort. The "coolers" filled with hot cans, are then passed through a "lye wash" to remove oil, washed with clean water, and dried with an electric fan.

More recently, after processing, the hot cans are cooled by running pressured cold water in a "retort" without taking out the cans. The cooled cans are taken from the "retort" and are passed through a "wiper", a wiping machine, or are wiped by hand.

After being dried, the cans are tapped on the distended ends with a short iron rod. Any can which has a dull sound is removed, as that sound is an indication that it is leaking; a ringing sound means that a considerable degree of vacuum exists within.

In the past, after being clinched the cans were passed through an "exhaust box". The function of the "exhaust box" was primarily to heat the filled cans sufficiently to drive out some of the air; it is necessary to have a vacuum in the cans after cooling to keep the ends concave under all conditions of temperature and altitude. When the cans are passed through the "exhaust box", they are exhausted for 6 to 8 minutes with live steam, having a temperature of 200°F (93 to 99°C). The hot cans from the "exhaust box" pass immediately to the "closing machine" ("double seamer") which rolls the tops on firmly, making the cans airtight. In many of the more modern plants the "exhaust box" has been eliminated by use of the vacuum-closing machine. This speeds up the canning operation to a considerable extent. The cans are usually labeled by automatic machinery after the export inspection at a shipping port.

There are many sizes of cases which contain 48 or 96 cans in a case in Japan. (cf. Table 4-13).

2. Precautions in the packing of canned salmon

Japanese canners always call their workmen's attention to the following precautions.

a. Handling of raw material for the packing

1) Do not use raw fish in condition of rigor mortis (red salmon is 24 hours after the arrival at the floating-cannery, silver salmon is 8 hours after the arrival), because if raw fish in condition of rigor mortis is used, the rotation of the dressing-machines is not smooth.

2) The complete processing of canned pink salmon must be finished within 24 hours.

3) Select the raw material according to freshness.

4) Remove any scarred part on the fish body with a knife.

5) Isolate into a separate lot any raw material which is sunburnt, and do not use such material for export.

6) When the catch is in piles, spread into thin layers.

7) The place on which raw fish are piled should be kept clean.

8) Wash the location with a water-jet before and after piling of fish.

9) When a spear is used, do not prick the fish body (only to the head).

10) As a washing water, clean sea water is adequate.

b. Dressing the fish

1) Keep a sharp edge on knives of "header" or "iron chink".
2) Take care to change water after the 1st washing for the 2nd washing.
3) When the dressed fish is soaked for a long time, meat discolors and smells. Take care as to the soaking time.
4) Wash carefully to remove dark muscle.
5) Appoint a supervisor to inspect the washing and select the grades of the fish.
6) Wash fish-tank carefully.
7) Remove fish from tanks in order of first in, first out.
8) Keep the edge of the "fish-cutter" sharp.
9) Keep the least possible the amount of water which drips down on the surface of the edge of a knife.
10) Do not cut the fish diagonally into pieces by a "fish-cutter".
11) In order to isolate tail and meat, devise a method for dropping these pieces from the belt or feeding chain-conveyor.

c. Filling cans

1) Keep the edge of the "filler" sharp.
2) Keep the amount of water as small as possible which drops on the surface of the edge of knives of the "filler".
3) Level the fill of cans at the "patching table".
4) Take care in the selection of meat pieces, and do not put in more than one piece of tail meat. Unless tall cans are used, pack the piece of tail meat having almost the same height of flat cans. The smaller pieces of tail meat should be used as supplemental meat.
5) When pieces of salmon meat are filled by hand, the supplemental meat should be embraced by the belly part of the pieces.
6) The number of supplemental pieces of meat should be more than four per can, except in the case of pink salmon.
7) Do not fill the hard and soft meat together into one can.
8) Do not fill pieces having different colors into one can.
9) Do not place the supplemental meat on the top of the contents, they should be placed in the inner part of the can contents.
10) Do not fill pieces of the meat, from different kinds of salmons

into the same can.

11) The filling table and other canning equipment should be periodically disinfected by sunlight (out of doors) or steam-jets.

12) Filled cans should be conveyed in the order in which they are filled to the "clincher".

13) Frequently wash the filling tables and workmen's gloves.

14) Permit workmen to take off their gloves when they are cleaning tables or are sharpening knives.

15) Prevent flies or boiler shoot from coming onto the filling table or filling equipment.

16) When the salt is put into cans by hand, weigh the salt; do not depend on eye-measurement.

17) In order to clean cans, in the case of machine filling, place the "can-washer" between the "clincher" and the "exhaust box" when an "exhaust box" is used.

18) Take care in cleaning the drainage from which an offensive smell is given off, corners of conveyor table and cracks in boards in which dirty dust is easily accumulated.

19) Disinfect gloves or other equipment which touch meat directly by boiling water or hydrogen peroxide solution. Do not use sodium hypochlorite solution or cresol-soap.

20) When sodium hypochlorite solution is used for cleaning tables or tanks from which an offensive smell is easily given off, rinse thoroughly with clean water to remove the smell of sodium hypochlorite.

d. Other procedures

1) Do not leave filled cans over 40 minutes in front of a retort without retorting.

2) Cool hot cans taken out from the retort as rapidly as possible.

3) Take care not to damage labels on cans.

4) Handle empty or processed cans with care to avoid injuring them.

5) Do not mistake printing marks on the outside of the wooden cases.

6) In order to prevent mistakes in nailing the wooden cases, mark the position of the nailing.

7) Remove any dust in empty cans before using; eliminate rusted or damaged cans; do not use empty cans, of which the "flange" of the can-body has been damaged.

8) Select out light weight cans, damaged cans and rusted cans which have processed, by tapping on the distended end with short metal rod after retorting and by visual observation.

The above cautions are important not only for salmon canning, but also for other canning procedures.

3. Grading of exported canned salmon

According to Japanese Government Regulations, the grade of canned salmon (except canned salmon neck meat) is indicated by two classes, A and B. A is called "Fancy", and B is "Standard".

The grade is determined by a score system. The export price of the canned salmon differs according to the species of salmon and the grades.

The grading and scoring are shown as a, a', b, b', c, d as Table 4-14. (In this Table, a', b' c, d are omitted.)

Table 4-14. The grading and scoring of canned salmon (solid meat)

Items inspected for scoring	Judging	a	b
Appearance of the content at time of opening cans	Appearance of free oil	Deep color oil covers almost all the surface of the content	Covers less than a half of the surface
	Amount of free oil	Above 5 cc of free oil for No.4 salmon can. Above 3 cc for No. 2 flat salmon can	Less than 5 cc of free oil for No. 4 salmon can Less than 3 cc for No. 2 flat salmon can
	Appearance of juice	Transparent	Somewhat blackened. Somewhat turbid. Pretty large amount of meat exposed

Items inspected for scoring	Judging	a	b
	Surface of the content	Almost smoothly flat, having no crack in the content ; not squeezed.	Remarkably uneven and many cracks
	Cross pack	None	Present
	Adhesion	None	A large amount
	Loose skin	None	
	Curd	None	Pretty large
	Fluffy	None	
	Dirty skin	None	
Contents (meat)	Body oil	Meat contains large amount of body oil and has moderate hardness	Deficient
	Water mark	None	A few
	Flesh firmness	Moderate	Deficient
Coloring (red salmon only)	Peculiar color	Favorable	Somewhat noticeable
	Assortment of different color meats	None	Large (assortment)
	Coloring	Talls under regulations as given in separate Table	Talls outer regulations as given in separate Table
Flabvor	Peculiar good flavor	Present	Somewhat deficient
	Abnormal odor due to feed, refrigeration odor, wooden odor, abnormally fermented odor or rancid odor	None	Pretty strong

Items inspected for scoring / Judging		a	b
	Salty taste	good	Somewhat salty
Other inspection items	Filling condition	Filled in good shaped, the content appears can-shaped when it taken out	Filled roughly, too much pieces of meat for respective can size
	Crossed packing	None	Present
	Number of tail meats	Less than one tail meat in No. 2 flat salmon can	Within 2 pieces of tail in No. 2 flat salmon can
	Presence of disfigured meat, meat having lack of regulation length, and fish fins	None	Not remarkable
	Removing of entrails	Completely	Pretty many
	Presence of scarred or bruised meat	None	Pretty many
	Cut surface	Being at right angle with bone, and surface is even	Cut diagonally, roughly
	Hardness of bone	Bone can be broken by light pressure of the fingers	
	Curd	None	
	Struvite	Very few crystals	Pretty many
	Blackening of inner side of cans	None	Remarkable
	Foreign matter or mix of meat of different species	None	None

Note a. The back bone is held between thumb and first tip and is crushed. Grade is assigned according to amount of strength required for the crushing. If the bone is too hard, it needs a strong pressure to crush it.

Note b. Explanation of terms in the grading and scoring Table:

1) "Dry pack" means that the amount of juice is too small to cover the whale surface of the content (meat), therefore a half of the surface is exposed.

2) "Cross pack" means that the meat is packed diagonally with other meat.

3) "Adhesion" means that the pieces or meat adhere to the inner side of the top of the can.

4) "Loose skin" is that skin which has risen from the content to float on the surface.

5) "Curd" is protein of the meat which has coagulated as white clots on the surface.

6) "Fluffy" means that fragments of skin or meat are floating on the surface.

7) "Dirty skin" means that fragments smaller than "fluffy" are floating on the surface making for a poor appearance.

8) "Water mark" means that the fish skin has become brown or mottled, e.g. the surface of red salmon skin becomes deep red or chum salmon skin becomes brown.

9) "Tail meat" is the meat nearest to the tail-fin after the tail-fin has been removed. The length of the meat adjusted to the can-height.

10) "Insufficient-sized meat" is meat of which the length is shorter than other pieces in the cans. But one piece of which the length is more than a half of other meat is permitted as a "insufficient sized meat" for No. 4 tall cans. If the "insufficient sized meat" is split and the back is removed from the meat, and if the split meat is then used as supplementary meat, such pieces are not regarded as "insufficient-sized meat".

Note c. Inspection practice:

1) Upon opening cans: -

Inspect the appearance of the contents upon opening cans.

Canned red salmon has the highest value, as it possesses a good deep red color of floating oil, and has red muscle, inspect those items carefully. The inspection of the appearance of the juice covering the surface of the content in No. 3 flat salmon can is scored according to an inferior grade by one step, a, a', b, b', c, d.

2) Condition of the meat : -

After emptying the content on a dish, first press the surface with the palm of one hand, and next hold the content with five fingers of the other hand ; thus inspect and score the hardness and firmness of the meat.

3) Coloring : -

Canned red salmon has the highest value because of its red color, but it may turned to be yellowish according to fishing ground where caught or kind of feed eaten. Young fish is light red, and old fish has less red color. With a loss of freshness, the brilliance and color decrease. When the canned salmon meat has an abnormal lustre (this is called "bright"), the freshness of the raw material used for canning was low.

4) Flavor : -

As soon as the content is taken out on a dish, smell of it. Odors are described as follows : (i) Hydrogen sulfide smell and related odors according to kind of raw fish, feed eaten and fishing ground ; (ii) Refrigeration odor, (rancid meat odor) ; wood odor caused by conditions of storing and handling of raw fish ; (iii) Rancid oil, histamine and indol odors characteristic of staleness in fish.

5) Other items : -

Inspect and assign a consolidated score (mark) for the condition of the dressing, packing, washing and presence of foreign matter and change in appearance of inside of can. If there were a bruise on the skin of the meat, if the change of color owing to the bruise stopped at dark meat layer and did not reach to the normal meat, it is not regarded as a bruise. The curd which is formed within the pieces of meat is not taken into consideration. The hardness of the back bone is judged by pressing between thumb and fore-finger. If the back bone is too hard, or the coloring of the meat shows it to be under-done, with appearance of understerilization, incubate the cans in an incubator at 37°C at least one week. Tail meat or tail meat having tail bone connected to the fin, of which the length is shorter than can-height is regarded as sundry meat.

6) The meat from which a belly part was removed for because of rancidity is regarded as damaged meat.

7) For grade A. The number of pieces of solid meat in No. 3 salmon-can should not be more than two. The number of pieces of supplementary meat should not be more than one.

4. Determination of grade and score of can-contents

In the grading and scoring of canned food, the marks empoyed are defined as follows:

a-a'	show excellent, and extra excellent is a.
b-b'	good, b' somewhat inferior.
c	inferior.
d	poor.

According to score-regulation, items having ◎ mark in Table 4-14 are considered important factors.

Score is determined as follows

(a) When all the items are "a" or "a' "; When one item not an important factor is "b" and other items are "a" or "a' ";	Score is A (100-80)
(b) When all the items are a-b', but do not fit in (a); When one item not an important factor is "c" and other items are a-b';	B (79-60)
(c) When there is one "c" in the items observed and they do not fit in (b)	C (59-50)
(d) When there is one "d" in the items observed	D (49-0)

5. Determination of grade of the quality of one case or of a lot of can cases

It is of course impossible to inspect all the cans in one case or in a lot of cases by opening each one. So a definite number of cans are taken from a case or a lot cases, and the cans taken are insqected as described in the previous section. ("spot check").

The number of cans taken at random from a case or of cases taken from a lot of cases is as follows:

The grade and score of a lot of cases, from which some cans were taken for grading and scoring inspection, are judged by the results of inspection of samples of a one time extracting system, as follows:

(a) When all the cans are "A" (Score described in the foregoing): or when the number of "B" is less than "Limit of number of passed or non-pased cans" (as described in Table 4-16) and when there is no "C" or "D";	A
(b) When all the cans are "A" or "B" and do not fit to article (a); or when the number of "C" is less than "Limit of number of passed cans", and when there is no "D"	B
(c) When the number of "C" is more than "Limit of number of non-passed cans"; or when there is one "D"	Below Standard

If the quality of the content of random-selected cans is judged A-class (Fancy), B-class (Standard), and other items also fit the regulation, "such a lot" is judged to be that grade respectively. And if the grade

Table 4-15. Number of sample cans taken out from a case or a lot of cases

Scales of lots of cases				Extracting Methods	No. of sample	Number of cases taken out
Containing 1/2 dozen	1-2 dozen	4 dozen	8 dozen			
cases 1-30	cases 1-10	cases 1-5	cases 1-5	One time extracting system		cases 1-2
31-60	11-30	6-10	6-10	〃		2-4
61-100	31-60	11-30	11-30	〃		3-6
101-300	61-100	31-60	31-50	〃		4-8
301-800	101-300	61-100	51-80	Two times extracting system	1st 2nd	4-8 4-8
above 801	301-600	101-300	81-200	〃	1st 2nd	7-14 7-14
	601-1200	301-600	201-500	〃	1st 2nd	11-22 10-20
	1201-above	601-1200	501-1000	〃	1st 2nd	16-32 16-32
		above 1201	above 1001	〃	1st 2nd	24-40 23-46

Number of cans taken out		
For Quality inspection	Reserved sample	Total
cans	cans	cans
2	0	2
3	1	4
5	1	6
6	2	8
7	1	8
7	1	16
13	1	14
13	1	28
20	2	22
20	0	42
30	2	32
30	2	64
45	3	48
45	1	94

Table 4-16. Limits of passed or non-passed cans

Extracting method	No. of sample	Dimension of sample	H	"Number of can"	Judgment passed	"Number of non-passed cans"
One time extracting system		2		0		1
		3		0		1
		5		0		1
		6		0		1
Two times extracting system	1st	7	7	0		2
	2nd	7	14	1		2
	1st	13	13	0		3
	2nd	13	26	2		3
	1st	20	20	1		4
	2nd	20	40	3		4
	1st	30	30	2		6
	2nd	30	60	5		6
	1st	45	45	3		9
	2nd	45	90	8		9

of the quality does not fit regulation, the lot containing such cans is rated "not passed".

Not only canned salmon, but also many other canned foods (for export) must be inspected by the "Japanese Canned Foods Inspection Association". As a sample, the inspection of canned salmon was explained above in special detail.

IV. Canned Salmon Neck Meat

In order completely to utilize the fish body, the neck meat of various kinds of salmon is processed by canning. According to the species used, it is called red salmon neck meat, etc.

The head of the salmon which was cut with a "head cutter" is prepared by cutting out the nose meat ("hizu") containing the sickle-shaped gill as shown in Fig. 4-3, by means of a round saw slicer. This is "neck meat". (cf. Fig. 4-3. in p. 97) A piece of neck meat weighs about 30 g. The neck meat is washed carefully with water in order to remove the kindney. The neck meat is packed into No. 4 tall salmon-can (net contents 450 g), No. 1 flat salmon-can (450 g), No. 2 flat salmon can (220 g), or No. 3 flat salmon cans (110 g) with the same amount of salt as regular canned salmon. The processing temperature is 115.8°C for 80-95 minutes for a No. 2 flat salmon-can.

Neck meat is sometimes prepared at old times when there is no processing of canned salmon (solid meat), thus the loss in freshness must be carefully watched. Therefore the accumulation of raw material should be avoided.

V. Canned Salmon in Tomato Sauce

Canned salmon in tomato sauce is processed only for export in to order. The quantity is not great. The raw material is principally "masou" or pink salmon which have a high fat content than other salmon. The processing is as follows:

Salmon is filleted in rectangles, of which the length is somewhat longer than the can-height. The cut meat is soaked in brine of Bé 15° at 60°F for 90 minutes. After soaking, water is drained off in a basket. The drained meat is dehydrated by steaming in the basket at 212°F for 30 minutes or by frying in vegetable oil at about 230°F. for 7-8 minutes. The dehydrated meats are usually packed in No. 2 flat can (180 g) or No. 3 flat can (90 g); tomato sauce is added (50 g or 25 g into the respective cans) and the cans are sealed. The sealed cans are sterilized at 226°F for 80-90 minutes.

VI. Canned Smoked Salmon

Among the several species of salmon, red salmon is smoked and processed for canning. This product is also for export. Fat red salmon is dry salted with 20% salt in a barrel, into which brine is poured. After salting for at least one or two weeks, the salmon is dressed to cut off the belly meat, desalted to moderate the salty taste in fresh water, drained, and then smoked at 65-70°F for 2-3 weeks.

The smoked back meat of red salmon is sliced into pieces which are packed in square cans (3 B) (solid content 75 g) with vegetable oil (olive or cotton seed oil) to make the net content 105 g. This canned smoked salmon is not heated for sterilization; this is in order to avoid discoloration of the smoked meat by heating. Therefore, all the equipment must be carefully disinfected, and the smoked salmon must be handled under a sterilizing lamp (ultra-violet light).

VII. Canned Seasoned Salmon with Bamboo Shoots

Canned seasoned salmon meat with bamboo shoots is used only for domestic consumption.

Salmon (chum or pink) is filleted and cut in round slices, of which the width is somewhat longer than the can-height. The cut meat is soaked in brine of Bé 15-16° for 60-90 minutes. After soaking, the meat is steamed on a basket at 210°F for 20-25 minutes. The steamed meats are packed in No. 2 flat can (steamed meat 120 g) or No. 3 flat can (60 g), into which cut seasoned bamboo shoots and seasoning juice (40 g or 20 g respectively) are added, and sealed. The sealed can is processed at 235°F for 60-80 minutes. The seasoning juice is made by boiling "Shoyu" (soy bean sauce) 1 litre, sugar 250 g and water 0.5 litre.

VIII. Fundamental Problems of Quality Control During the Processing of Canned Salmon

1. The scoring standard for the inspection of export canned salmon

Canned salmon for export is graded into A and B classes under the scoring standards set by the Japanese Canned Foods Inspection Association.

The scoring standard which has been shown as in Table 4-14 (p. 103) is determined mainly by organoleptic test.

The quality depends on the following conditions: fishing season, fishing ground, filling, freshness of raw material, processing, etc. For example,

a. Factors influencing appearance of canned salmon
  1) Appearance of floating oil on the packed meat is related to — Fishing season, fishing ground, and freshness.
  2) Amount of the floating oil — Fishing period, species of fish.
  3) Transparency of juice — Freshness.
  4) Appearance of the top of the packed meat — Freshness.
  5) Cross pack — Filling.
  6) Adhesion — Freshness.
  7) Loose skin — Freshness.
  8) Curd — Freshness, treatment before filling.
  9) Fluffiness — Freshness.
  10) Dirty skin — Freshness.

b. Flesh
  1) Body fat — Fishing season, fishing ground, freshness.
  2) Water marks — Fishing period, freshness.
  3) Firmness (texture) — Freshness.

c. Color of meat
  1) Characteristic color — Fishing period, fishing ground, freshness.
  2) Mixing of different colored meat — Filling.

d. Flavor
  1) Characteristic flavor — Freshness.
  2) Abnormal flavor (e. g. petroleum odor, wood odor — Bait, refrigeration odor, odor of rancidity — Storage of raw fish)
  3) Saltiness — Amount of salt added.

e. Other items

1) Condition of packed meat — Filling.
2) Cross pack — Filling.
3) Mixing of tail meat, broken meat pieces of fish body from which viscera were incompletely removed, bruised fish-Filling.
4) Conditions of cut surface of meat — Filling.
5) Firmness of bone — Processing temperature and time.
6) Presence of crystals (struvite) --Rate of cooling after the processing.
7) Blackening of inside of the can container — Freshness, processing, storage.
8) Presence of foreign matter — Filling.

2. Objectives of Quality control

The quality of canned salmon is based upon the color, flavor and odor of its flesh and juice. In controlling the quality of canned foods, there are two important factors, viz. natural environmental factor and factors influenced by artificial treatment.

The natural factors can not be controlled even by the most careful treatment, but treatment factors can be changed. For example, the size of fish caught can not be changed, but the loss of freshness can be prevented by the proper handling of raw material; or if the can filling operation carried out carefully, the product will have a superior appearance and claims by the consumer will be avoided.

3. Influence of fishing period, fishing ground and the freshness

It has been adequately pointed out by many investigators(1)(2) that the chemical components of raw salmon very according to the fishing period. Canned red salmon has the highest economic value because it has a beautiful red color of meat and oil. The amount of oil in canned red salmon varies according to the fishing period. The amount of oil present is especially great before spawning. The color of the meat and oil also vary according to fishing ground and the diet of the fish. The red color of red salmon meat is said to be due to the consumption of copepoda(3). The meat of red salmon which eat only small amounts of copepoda is yellowish-red. The meat of young or old red salmon is light.

The color of red salmon meat loses lustre becoming colorless with a decrease of the freshness. The color of stale meat shows abnormal lustre and red color, so called "Bright".

After spawning, the skin of salmon is mottled. The skin of red salmon becomes mottled red while that of chum salmon becomes mottled brown. This mottled condition is called "water mark".

It has been generally considered that an abnormal odor in canned salmon is seldom caused by the fishing ground or food consumed. However, Tanikawa and Motohiro(4) have studied the petroleum odor in canned chum salmon and have demonstrated by gas chromatography that the chemical component which causes this odor is dimethyl sulfide. This sulfide is formed in the canned chum salmon meat from dimethyl-β-propiothetin which is transported from pteropoda (*Limacina helicina*), a kind of plankton, eaten by chum salmon. The pteropoda (*Limacina helicina*) contains a comparatively large quantity of dimethyl-β-propiothetin. Dimethyl-β-propiothetin is slightly decomposed in the digestive organs or meat of chum salmon; if this component remain in the meat it changes to dimethyl sulfide during heat processing. On the other hand, red salmon do not much eat pteropoda, and even if pteropoda have been eaten, dimethy-β-propiothetin will be changed to methionine by combining homocysteine by transmethylase in the liver. Thus canned red salmon has no petroleum odor. In canned pink salmon also, there is a only rate occurrence of such an abnormal odor. The development of petroleum odor in canned chum salmon due to dimethyl sulfide has been found to be accelerated by the presence of volatile phosphoric compounds in meat add bone.

Many studies on preservation the freshness of raw salmon have been carried out.(5)(6)(7)

Early in 1950 a number of the antibiotics were tested, and it was found that chlortetracycline (CTC), terramycine (OTC), and chloromycetin, in 10 μg/g concentration retarded bacterial spoilage of fish flesh.(8) More extensive investigations were then carried out to preserve salmon.(9)(10)(11) Flake-type ice containing about 1 μg/g of CTC was compared with ordinary ice under practical fishing conditions on salmon boats. The results showed that an outstanding improvement in keeping quality of coho salmon resulted from use of the CTC ice.(9) The similar results were obtained by many investigators.

In Japan, Tomiyama et al. have studied on the penetration of CTC into tissues of sockeye salmon on CTC-dip treatment and its destruction on heating.(12) It was observed that not only the skin but also the operculum, the fin and the gills contained a large amount of CTC whereas the flesh only less than 0.13 ppm and the gut less than 0.01 ppm. The assay for CTC in several thin layers of flesh under the skin showed that no penetration of CTC occurred in flesh deeper than 3 to 4 mm from the skin. The canning of the treated fish inactivated the penetrated CTC completely. Such cooking procedures as boiling, broiling and frying also destroyed the CTC residues on fillets cut from the treated fish. The rate of inactivation of CTC at 95-99°C conformed with the first order reaction.

With respect to preserving effect by icing with furylframide (2-furyl 3-(5-nitro-2-furyl) acryl amide), chlortetracycline, and tylosine on chum salmon caught near the sea of Hokkaido, an investigation was carried out.(13) Preserving effect of icing with furylframide (5 ppm) and with tylosine (5 ppm) is almost similar to that of icing with chlortetracycline (5 ppm). Although icing with various preservations is effective for preserving raw salmon, the elongation of storing period, results in belly-burn which causes a canned product of lesser quality. Thus pre-treatment of raw salmon with butylated hydroxytoluene may prevent the belly-burn through the period of icing with various.

4. Relation between freshness and quality of the canned product

The freshness of the raw fish has a great influence upon the quality of canned salmon. When raw fish at the lower levels of acceptable freshness is used, the texture of the meat is usually softened by autolysis, and the skin becomes easy to remove. When salmon of a quality below this level of freshness is used for the canning, it becomes "Fluffy" or "Dirty skin" which means fragments of skin or meat float on the surface of the canned content. Furthermore, the juice of the canned salmon becomes turbid due to a dissolving out of the protein, while the meat looses its characteristic sweet odor and develops ammonia, indol and hydrogen sulfide odor.

When frozen salmon is used as the raw material for canning, some smell called "freezing smell" assails one's nostrils on opening of the cans. Tanikawa and Motohiro(14) have observed that if the storage time of frozen salmon is over 50 days, the freezing smell becomes pronounced. If an antioxidant such as butylated hydroxyanisol is added before freezing, the storage time can be prolonged to about 80 days.

Then what is the limit of freshness of raw salmon for canning? According to Tanikawa(15) the limit of the freshness of raw salmon is considered to be about 20 mg% of the amount of volatile basic nitrogen (V.B.-N) in the raw meat. At the present time, almost all the procedures for processing of canned salmon are carried on by machine, e.g. iron chink, cutting machine, filling machine. Under these conditions, if the raw salmon is very fresh and in pre-rigor or in rigor, the meat does not pass smoothly through the machines. Hence, the meat after the stage of rigor mortis is better as raw material. In this case, the limit of freshness should be up to about 20 mg % of volatile basic nitrogen, in otherwords, in the condition prior to incipient autolysis.

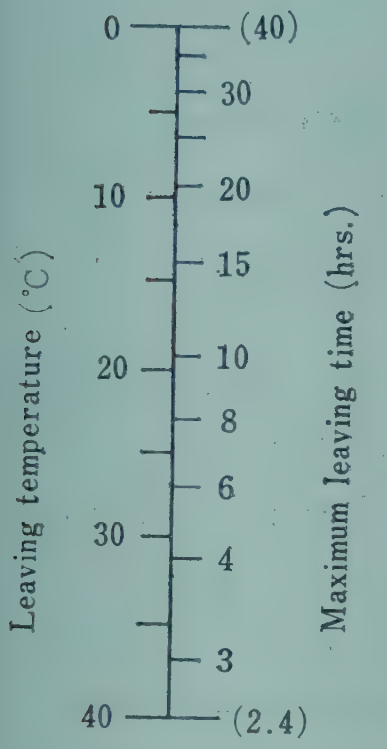

Fig. 4-4. A scale showing the maximum storing time reaching to 20 mg% V.B.-N.

Tanikawa(15) has published a scale showing the maximum storage time (t_{20} hours) for reaching the limit of acceptable freshness at various temperatures, as shown in Fig. 4-4.

IX. Technical Problems Related to the Processing of Canned Salmon

1. Faults in the canned salmon

There frequently happens so-called "adhesion" or "curd" in canned salmon. These faults present poor appearance when the cans are opened.

"Adhesion" means that the meat adheres to the inner side of the cover of the can. The cause of such adhesion is considered to be due to the raw meat coagulated by heating coming in contact with the inner side of the cover. To prevent the development "adhesion", the inner side of the can is moistened with distilled water(16) or with 0.1 % silicon resin solution(17) before the filling.

Curd is often formed in canned salmon, mackerel, and other fish, soft white or sometimes stiff grey coagulation covering the surface of the flesh.

Curd has been investigated in canned salmon,(18)(19)(20)(21)(22) and canned mackerel.(23)(24) The data in these papers have showed that heat coagulable proteins are a constituent of the curd. In relation to the formation of curd and frozen of fish, the amount of drip which contains heat coagulable protein increases during freezing storage in fish flesh, hence the amount of curd from frozen materials is always more than that from raw fish.(24)(25)

Akiba et al.(25)(26) have studied on the formation of curd by heating salmon flesh which had been handled with different storing of thawing methods. According to them, the amounts of curd from frozen salmon varied in accordance with heating temperatures, increased from 40° to 60°C, decreased at 70~80°C, and again increased above 80°C. Constituents of curd in flesh move out from gaps made by heat shrinkage of muscle tissue itself. A factor such as mechanical damage on frozen salmon should be taken into consideration regarding curd formation. If the degree of injure to the flesh becomes worse, the amount of curd increases as well. Degree of thawing flesh may associate with the amount of curd. Complete thawing results in less amounts of curd in canned products than un- and half-thawing.

To prevent the formation of the curd, the raw meat is soaked in brine of about Bé 3° for 20~30 minutes before being filled into the cans. If such brine-soaking is employed, the amount of salt added to the content must be decreased. Recently, Motohiro et al.(27) have proposed a method to soak salmon flesh in 0.5M sodium dipicolinate solution for 15 minutes since sodium dipicolinate may prevent denaturation of myogens and myosins by heating. Soaking and heating salmon flesh in 3M urea solution for 15 minutes is also available as the reagent may unfold heat coagulated proteins.(28)

2. Processing temperature and time

Canned salmon processed on a mother-ship factory has a low degree of contamination as fresh raw material is used. On the other hand, canned salmon packed in a land factory frequently exhibits swell or other spoilage owing to the use of lower quality of raw material, and especially owing to the fact that the processing temperature-time is not adequate. The causes of the swelling or spoilage of canned salmon have been investigated by many investigators.(29)(30)(31)

Among the bacteria isolated from the spoiled canned salmon, *B. cereus, B. subtilis, B. cereus, var. mycoides, B. mesentericus* (*B.subtilis var.*), which are thermotolerant bacteria, were found. These bacteria have been frequently found on the floor, or in the soil around a cannery.

Generally canned salmon in No. 2 flat cans (a half pound) is processed at 10 lbs-pressure (118°C, 239.4°F) for 80 minutes. If fresh salmon (below 20 mg % of V.B.-N.) is processed by this above mentioned procedure, adequate sterilization is achieved. But if the freshness of the salmon is below this level and it contains a higher bacteria content such a process may not be adequate to pre~~s~~vent spoilage.

Tanikawa(15) has prepared a consolidated scale showing the relationships between the holding temperature of raw salmon, loss of freshness and the processing temperature and time required for canned salmon (Fig. 4-5). By this scale, the freshness of raw salmon can be ascertained, when the storage time of raw material from catching to processing and the storing temperature are already known. Next, when the degree of freshness is known, an adequate processing time may be determined for a given processing temperature. For example, if the temperature in the cannery is 25°C, the coefficient ("p") of the decomposing velocity in the initial stage is known to be 0.023. Then if the leaving time of the raw material is 20 hrs. after unloading into the cannery, the increase of volatile basic nitrogen is 2.0 mg% and the number of bacteria is 10^4/g. If the number of bacteria is 10^4, the processing time is 73 min. at 10 lbs pressure, and 59 min. at 12 lbs pressure, assuming *B. megatherium,* and 87 min. at 10 lbs pressure assuming *Cl. botulinum.*

The backbone in canned salmon must be easily crushed with the teeth when it is eaten. The degree of softening of the backbone is related

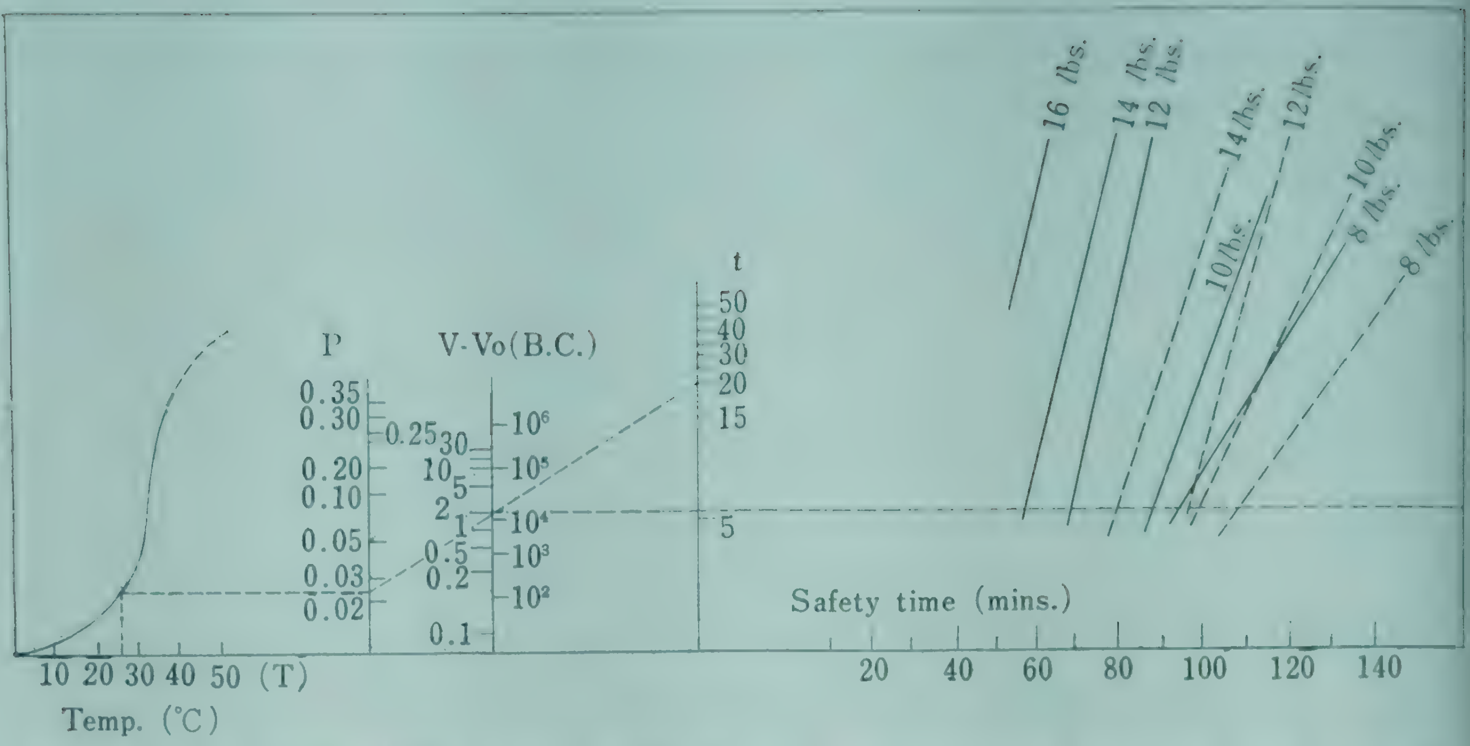

Fig. 4-5. A consolidated scale showing the relationships between the holding freshness and the processing temperature and time required for canned salmon

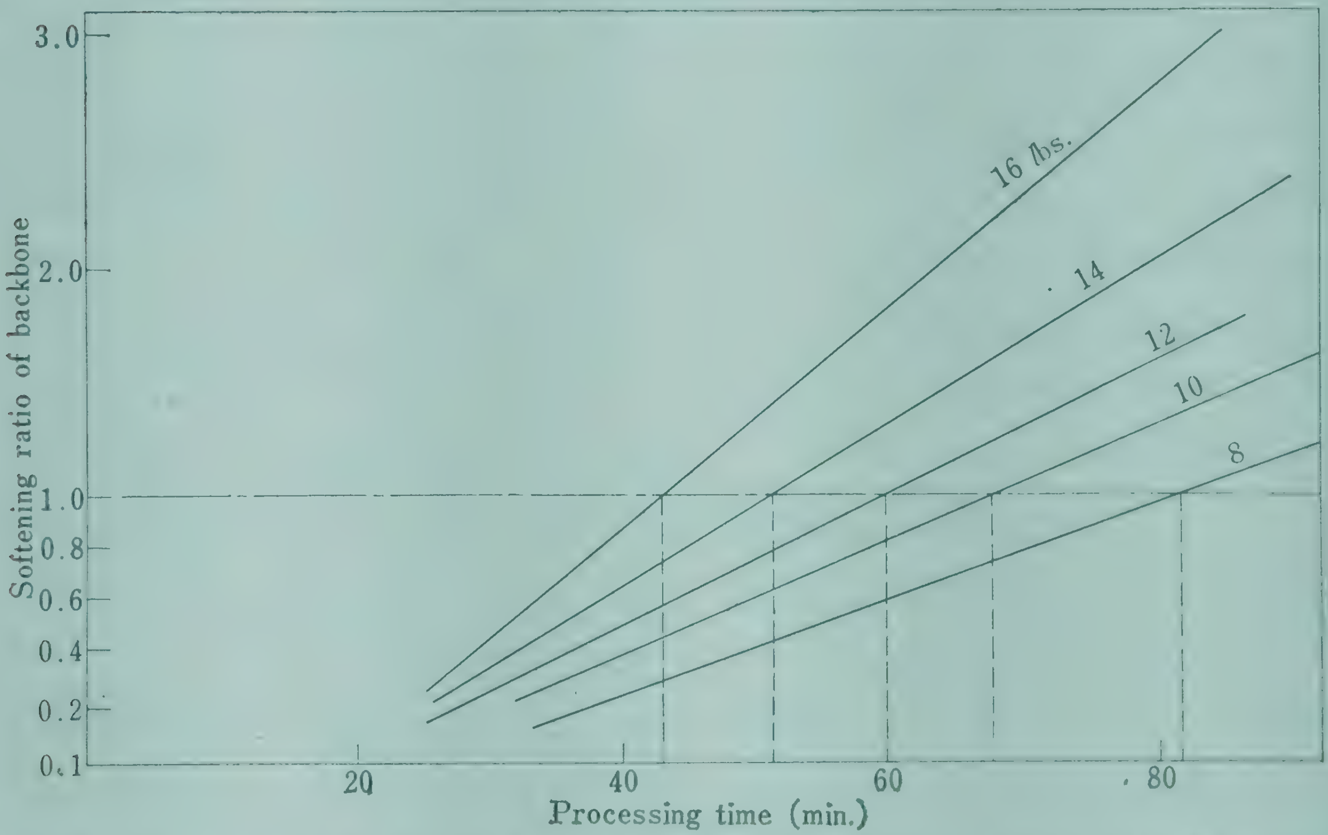

Fig. 4-6. Curves showing the relation between the "softening rate value" of canned salmon and various processing temperature and times

to the processing time and temperature. Here, two factors must be considered: the rate of heat-penetration in the canned salmon and the retort temperature. In the grading of canned salmon by organoleptic examination the hardness of the backbone which is considered to be satisfactory for eating, is called "optimum hardness of bone". This is 6 kg/cm² from the analysis of the experimental results which were obtained by Matsuike et al.(32) Times required to soften the backbone of several kinds of salmon when processed at various temperatures, are shown in Table 4-17.

Table 4-17. Time required to soften the backbone of salmon at various processing temperature

	Pink Salmon	Chum Salmon
5 1b-pressure	90 min.	40~60 min.
10 1b	40	25
15 1b	20	10

Tanikawa(15) has called the relationship between the time required to soften the backbone and the processing temperature, the "thermal softening time curve". The reciprocal of the time required to reach optimum softness of bone is called, "the softening rate value". Curves showing the relation between "the softening rate values" of canned salmon and various processing temperature and times were presented.

According to these curves, for example, the backbone is softened by processing at 12 1bs-pressure for 60 minutes, 10 1bs-pressure for 68 minutes, and 8 1bs-pressure for 82 minutes. In the processing of canned salmon, the softening of the backbone and the destruction of bacteria must be considered.

3. Appearance of pack and quality

In the regulations for inspection of canned foods, normal meat must be packed in a manner to give a good appearance. Therefore, pack the meat so as to make the surface of the content flat and of good appearance, do not pack different colored meat, do not pack the meat crosswise, do not mix tail meat, insufficient sized meat, fish meat from which viscera were incompletely removed, and bruised fish meat, etc. At the time of packing, these prescribed rules must be followed.

Trouble has happened in the past, "springer of canned salmon", which was frequently caused in tall cans by packing salmon meat crosswise(33). The air remaining in the gaps between the cross packed meat will be expanded by an increase of ambient temperature and by a decrease in atmospheric pressure. Such expanded air may cause "springers" to in canned salmon (tall can).

4. Formation of glass-like crystals (struvite)

Not only in canned crab, but also in canned salmon, glass-like crystals (struvite) have frequently been found, which cause trouble and complaints in commercial business and consumers. The chemical components of these crystals have been indentified as $MgNH_4PO_4 \cdot 6H_2O$. Tanikawa and Nagasawa[34] have studied the cause of their formation. Each component of the crystals is always present in marine canned foods. For example, Mg is present in the meat of marine creatures or in washing water (sea water), NH_4 is present as decomposition compound in the meat, and PO_4 is also present in the meat and bone. During the processing the compounds will combine together and when the cans are cooled, the combined components will crystallize out. Therefore in the liquid of all kinds of marine canned foods the crystals are always found either in microscopical size or in sizes visible to the naked eye. The enlargement of the microscopic sized crystals to visible size can be related to the cooling velocity of the cans after processing. Tanikawa and Nagasawa[34] have found that the zone of the maximum growth of crystals is 40°~50°C and the time the cans remain within that the zone as shown in Table 4-18.

Table 4-18. Time remaining at the zone of maximum enlargement of crystals in canned salmon

Rapid cooling in running water	Medium cooling in shower water	Slow cooling by fan
17 minutes	28 min.	29 min.

In the cooling of cans after processing, if the cooling velocity is slow, the temperature at the center will remain longer at the zone of the maximum enlargement of crystals than in the case of rapid cooling.

Table 4-19. The maximum growth of $MgNH_4PO_4 \cdot 6H_2O$ in various zones of temperatures (μ/min.)

Zone of temperature	Above70°C	70°~60°	60°~50°	50°~40°	40°~30°
Long axis	3.25	3.14	2.48	5.35	1.85
Short axis	0.00	0.63	0.41	1.84	0.14

In the cooling of canned salmon, the time remaining at this zone varies with the cooling velocity, as shown in Table 4-19.

For the formation of the crystals, the presence of the Mg component is essential. If the Mg-component is absent in the mixed solution, the struvite can not be formed. Therefore, if a complex salt-making agent such as hexametaphosphate is added to canned foods, crystal formation will be retarded or prevented. Such a method is employed in the U.S.A.

5. Changes in quality during storage

a. Loss of vacuum

The vacuum in canned foods decreases when they are transported to places of higher temperature. For example, when canned salmon having 10 inches of vacuum at a port in Japan was transported to the South Sea Islands, the vacuum decreased to 0~1 inch. Such a decrease in vacuum has caused trouble in commercial channels. Matsuike and Miyauchi(35) have studied the cause of the decrease of vacuum in canned salmon and have shown that it is due to the change of the volume of air in the head space or is due to a change in the volume of the meat owing to a change in its texture. The decrease was about 1.7 inches per 10°C increase of atmospheric temperature. Therefore, the vacuum in canned foods for export must be above 10 inches at the time of shipment.

b. Influence of freezing on quality of canned salmon

If canned salmon are stored at below freezing temperature, the contents are frozen and the ends of the container may swell. According to Hashigami and Ayabe(26) the freezing point of canned pink salmon is $-3.5° \sim -4.5°$. If canned salmon is stored at below this point, the cans freeze and swell. When frozen canned salmon is thawed and is refrozen again, its color and taste change only slightly, but the texture softens. When frozen canned salmon is thawed and is stored at room temperature, its chemical components will change. Therefore canned salmon should be stored at above freezing temperature.

6. Objective estimation of quality

Although the estimation of quality of canned salmon has been done by organoleptic tests, but it is desirable to employ objective method.

The Japanese Canned Foods Inspection Association has employed "Mertz and Paul's Dictionary of Color" for the estimation of canned salmon meat and oil.

Many investigators have studied the determination of grade by estimating chemical components. For example, such tests include: percentage of protein-nitrogen in relation to the total amount of nitrogen in canned salmon meat and juice(37), amount of volatile basic nitrogen(38), amount of hydrogen sulfide(39), and amount of indol(39)(40)(41) were employed. While such tests are effective in evaluating quality, it is undesirable to have to take a long time to carry on such tests. Hence, they are employed only in required cases of necessity.

7. Relationship between color intensities of raw and canned red salmon

Red color intensity of canned red salmon is an important factor in rating the quality of this product for export. More than 80 percent of the down-graded canned red salmon were so graded because of loss of red color intensity. It is known that discoloration on salmon flesh results from biological factors, such as age, sex, spawning season, or feeding, and also on the heat treatment during canning. The muscle pigment of salmon is a carotenoid, and astasin was isolated from salmon flesh. In living salmon the pigment is not astacin but astaxanthin.(42) Astaxanthin in salmon flesh ranges from 0.4 to 3.6 mg%, and changes to an isomer or an oxidized derivative during storage, resulting in discoloration. Approximately 36 percent of astaxanthin in the flesh is destroyed during canning, and small amounts are lost during subsequent storage of the canned product.(43)

Suzuki et al.(44) have investigated the changes in astaxanthin content in red salmon flesh during canning and the relationship between color intensities of raw and canned red salmon. The decrese in a-values and the increase in b-values after canning clearly affect the change from red color to yellow color intensity which can be observed during heat processing of red salmon. The relation between astaxanthin content in red salmon flesh before and after heating can be calculated as 7 to 5. From this correlation the color intensity of the finished product can be estimated by measuring the color intensity of the frozen material prior to processing.

The astaxanthin content of salmon flesh decreases due to heat processing. The pigment level gradually decreasing when the flesh was heated for 10 min. at temperatures between 50° and 90°C, but more rapidly at the higher temperatures. Temperatures above 90°C should thus be avoided for heat treatment of salmon flesh. The astaxanthin content also declines gradually during heating at 115°C, but it tends to drop more rapidly after 30 to 40 min.

Schmidt and Idler(45) have proposed the following formula for estimating the color intensity of canned salmon from that of the raw material using a-values measured by colorimeter: $a_C = 0.550\,aR + 0.786 \cdots\cdots\cdots (1)$

where: a_C=a-value for canned salmon

a_R=a-value for raw salmon

both derived from tri-stimulus values (X, Y and Z).

Appling the a_R-value to this equation, a_C values obtained experimentaly. It will be seen that the difference between the two is within ±2, which would suggest that the formula proposed by Schmidt and Idler could be applied for practical use.

Some modification of equation (1) would, however, be necessary if it is to be used for salmon caught in the North Pacific during the main season. During this time variations in color intensity are significant due to different feeding habits. This constant in the equation of 0.786 which relates to salmon of a similar biological state would therefore not be applicable. A more general equation would be more appropriate.

$$a_C = 0.550\,a_R + Ts \cdots\cdots\cdots (2)$$

Where the Ts value will depend on the examination of the biological condition of the fish at any particular time, and will vary throughout the North Pacific salmon season.

8. Relation between coated-cans and the smell of canned salmon

As a method of preventing the blackening of various kinds of canned foods, coated-cans have been employed. At the time, the coating is to cover the thin layer of electric tin plate on the inner side of the cans in order to prevent rust formation. When the uncoated cans (white cans) were employed, even if the unfresh raw salmon is used, of which the freshness had fallen (about 30 mg% of V.B-N. content), the decomposed components will react with the metals of the inner side of the container, and form so-called "the smell of the canned foods", which covers the smell of the decomposed meat. On the contrary, in case of using the wholly-coated cans, there is no exposed metal to react with the smell of decomposed meat, so the fishy smell assails one's nostrils at the opening of the cans. Then what degree of raw salmon results in the smell which assails to one's nostrils?

When the fresh raw salmon having V.B-N. below 20 mg% was used, the smell was not affected by the kinds of cans. But when the degree of fresheess of raw salmon fell, of which the amount of V.B-N. was above 20 mg%, the fishy smell or decomposed smell assailed one's nostrials from material in cans coated at top and bottom or from wholly-coated cans. Whereas, in white cans "the smell of canned foods" was clearly detected, but the smell evolved from the decomposed meat was inconsiderable. If coated-cans are employed, therefore, the freshness of raw salmon should be below 20 mg%.(15)

SARDINE-CANNING INDUSTRY

I. Sardine Fishery in Japan

1. Annual variation of sardine catch

In Japan, the term "sardines" includes sardine ("maiwashi", *Sardinopus melanosticta*), anchovy ("katakuchi-iwashi", *Engraulis japonica*), and round-herring ("urume-iwashi", *Etrumeus micropus*). The former two are important in commerce.

The total tonnages of sardine catches including anchovy and round-herring for the years 1936 to 1958 are shown in Table 4-20. Before the year 1926, the catch for 1920 and succeeding years amounted to about 500,000 metric tons, the figures rose gradually in line with the progress of fishing practice, and in 1925 they reached about 600,000 tons. A further sharp gain was registered in 1930, when the figures were more than 1,000,000 tons for Japan proper. With catches in Korea and Formosa added (before World War II), the figures reached over 1.1

Table 4-20. Annual variation of sardine catches

Year	Catch (tons)	Year	Catch (tons)	Year	Catch (tons)
1936	1,628,269	1951	665,010	1966	481,210
37	1,207,954	52	637,298	67	441,040
38	1,084,395	53	660,038	68	458,830
39	1,091,089	54	620,378		
40	856,699	55	669,229		
41	1,198,695	56	641 572		
42	860,940	57	716,415		
43	586,545	58	633,677		
44	270,849	59	551,482		
45	260,054	60	497,535		
46	357,604	61	544,713		
47	348,960	62	510,935		
48	375,353	63	424,074		
49	427,376	64	382,774		
50	562,793	65	477,018		

million tons. The catches until 1945 are the total catch including Korea and Formosa. The total catch of sardines in 1936 was 1.6 million tons. However, since 1942 the catch has decreased rapidly and reached a minimum (0.26 million tons) in 1945. The catch has been recovering since 1946, but has amounted to only about 1/3 of the maximum catch. In respect of quantity, the catch of sardines outranked all other fish in Japan before the World War II. The cause of the decrease of the catch is said to be mainly due to changes in the natural environmental factors.(46)(47)

2. Varieties of Sardines

Sardines used for canning in Japan belong to *Sardinopus melanosticta* of the *Clupeidae* Family. Fish 3.5 cm to 10 cm in length are called "small", fish 10 cm to 18 cm are called "medium", and fish above 18 cm (2 years old) are called "large". "Medium" sardine are canned in tomato sauce, while those below 13 cm in length are processed in olive oil. *Sardinopus melanosticta* has a dark green back. The dorsal surface is silivery white, while the side of the fish is characterised by a single raw of blackish blue spots generally ranging up to 7 in number. Primarily, this species of sardine is found abundantly in schools in waters near both northern and southern Japan with a temperature of 15° to 20°C, generally at about 8 meters below the surface. During the period from January to May of each year the fish come near to the coast or into bays, and swarm near the surface of the water. After spawing in the autumn they leave the coast and head toward the open seas.

The anchovy is mainly salted or boiled and dried. This fish also has a dark green back. The dorsal surface silvery white, and the side of the body is characterised by a single silvery white line. The size of this fish is less than that of sardines. This species is widely found in waters from Hokkaido (northern part of Japan) to Kyushu (southern part of Japan), especially in southern Japan.

Round-herring has a rounder body than the sardine. A cross section of the body is almost circular. This fish has a light green back. The dorsal surface is silvery white. The size is considerably larger than that of the sardine. This fish is found in waters of southern Japan. Its fat content is less than that of the sardine. This species is used for dried products.

3. Fishing grounds and fishing periods

The "small" sardines are found in all waters off the coast of Japan proper through the year. The "large" sardines are found from December to the following June, especially February to May. These fishing seasons are related to the time of spawning. The principal fishing grounds changed from the Pacific Ocean to the Japan Sea after World War II. The changes of sardine fishing seasons and fishing grounds are shown in Fig. 4-7.

4. Fishing methods

Nets adopted for sardine fishing in Japan include the "sardine net", "hand seine", "improved purse seine", "drift net" and "pound net" The size of the "hand seine" varies from 33~95 meters each. There are two kinds of "improved purse seine", one being operated by 1 boat and the other by 2 boats. The former is operated from a ship of about 10 tonnage, while the latter is operated by smaller boats of 6 feet in width.

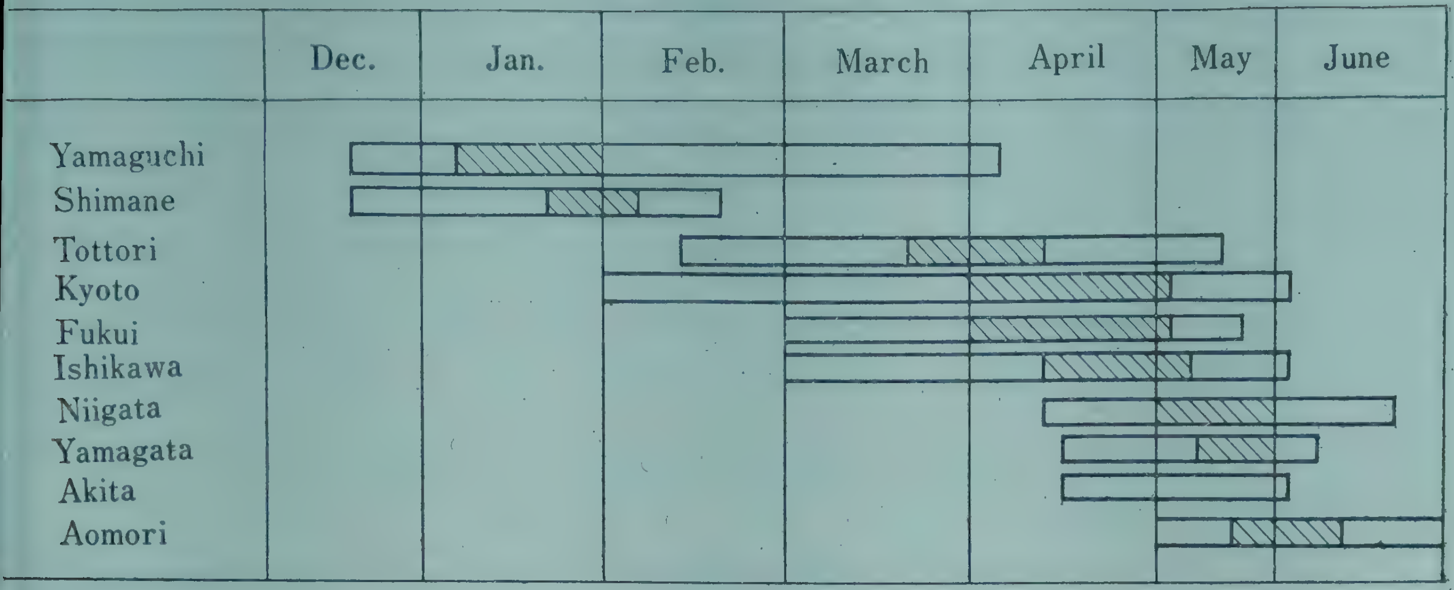

Fig. 4-7. Fishing seasons and fishing grounds

Note: Shaded portions show the most active fishing season

Each of the boats generally has in general a crew of about 10, and as schools of fish appear in the offing the boats rush to the spot to surround them. A "drift net" is operated by 3 small fishing boats, each having a crew of about 18. The net is left drifting with the current generally from sunset to the following morning. There are a few varieties of "pound nets" used for sardine fishing in this country. They are set in the regions frequented by the fish.

As above mentioned, the total annual catch has increased recently, but it is only about 1/3 of the maximum caught in 1936. Almost all of the catch of sardines, round-herring and anchovy is either dried after boiling or simply salted and dried. Some of the fish are used as fish scrap, when they are caught abundantly at one time. Among the three species, sardine is canned in tomato or processed in olive oil. Round-herring has also recently been untilized for canning, but the greater part is dried or salted for food, while some is consumed raw. Anchovy is consumed raw, dried or canned in oil, and as bait for tuna fishing.

5. Sardine-canning industry in Japan

The tomato sardine canning business was started very recently. In fact, it was only about 1923 that the first Japanese tomato sardines were packed on an experimental basis and some trial shipments were forwarded to Singapore. In 1925, about 3,000 cases of canned tomato sardines were shipped to the South-Sea countries. These shipments brought fairly satisfactory results, and consequently many canneries were established. More recently the international trade situation has developed with amazing rapidity in favor of canned tomato sardines packed in Japan, many new canneries were established in rapid succession at various places, in Japan, particulary in Kyushu and Hokkaido. But a majority of them were operated on a small scale. The aggregate production of tomato sardine jumped to about 250,000 cases in 1932. As above mentioned, with the decrease of catch of sardines, a majority of the canneries have ceased to exist.

The packing of sardines in tomato sauce is a very recent development, while sardines in oil may be claimed to represent the pioneer canning

Table 4-21. Production of canned sardine in 1967

Kind	Can size and no. of cans per case	Real no. of cases	Converted no. of cases (48 one 1b case)
Tomato	No. 4/4 dozen	688	650
sardine	Oval 1/2	11,723	5,536
	〃 3/4	24,938	11,913
	Small No. 1/100 cans	4,400	3,157
Total		41,749	21,256
	No. 6/4 dozen	1,251	584
Seasoned	6/8	25	23
sardine	Oval No. 1/2	2,064	975
	3/4	29,280	13,012
	3/8	258	229
	Square 3 B/50 cans	18,803	4,351
	〃 5 A/50 〃	425	216
Total		52,106	19,390
	Square 3 B/50 cans	45,441	11,042
Sardine	〃 〃 /100 〃	794	386
in oil	〃 P 7/50 〃	876	112
	1/6	107	18
	Oval 1/2	13	6
	〃 3/4	4,042	1,796
Total		51 273	13,360
Others	Oval 3/4	856	380
Sum grand		145,984	54,386

industry in Japan. Such packing has been traced back as far as 1869, when machinery imported from France was first used. Further studies were made at the Fishery Experimental Stations in Chiba and Aichi Prefectures with successful results.

After 1905, some packing companies were established. However, owing to various factors, these enterprises were discontinued 3 or 4 years later. World War I gave a fresh impetus which resulted in a revival of the oil sardine industry and exports soon reached 30,000 cases annually during that war. Immediately after the conclusion of the war, most of the canning plants of oil sardines went out of existence. With the increase of the catch of sardines from 1927 to 1941, the number of sardine-canneries again increased. But after the conclusion of World War II, and with the successive decreases in the catch since 1945 up to date, the number of sardine canneries has has again markedly decreased.

Table 4-22. Export of canned sardine in 1968

Kinds	Can size and no. of cans per case	Total number of cases exported (real number)	
Tomato sardine	Oval No. 1/4	7,940	Malaya, New Guinea, Pacific Ocean islands Hongkong, Holland, Belgium, West Africa, U.S.A.
	〃 3/8	2,915	Philippines
Total	100 cans	146,704	
(converted no. of cases)		10,284	
Sardine others	Square 5A/50 cans	600	South-Sea countries
Total		600	
(converted no. of cases)		153	
Grand total		11,455	
(converted no.)		10,437	

II. Canning Processes

1. Tomato sardines

Before packing the fish bodies into cans, they must first be dehydrated. For dehydration, there are some applicable dehydrating methods used in the tomato canning industry of Japan such as sun-drying, cabinet dehydration, cooking in oil and the raw pack (steaming). The oil frying method has been practiced for a long time, but it is too expensive. The less expensive raw pack method is popular at the present time.

a. Procedures

After being caught, the fish are transported to canneries, and the heads and viscera are removed. Immediately after being thoroughly washed, the fish are put through the drying process.

For drying, the automatic conveyor type drier is used, with a drying temperature of 110°～120°F. The fish are kept in the drier for 50 to 60 minutes, during which time they lose moisture to the extent of about 6 % of their weight. By another method, fish are sun-dried. But in this case, the fish usually developes a rancid flavor. The dried fish are then put into boiling oil, which is kept at a temperature of 225° to 240°F. In this process the weight of the fish is further reduced by 6 to 7 per cent. By these processes the enzymatic activity contained in the flesh of the fish is destroyed, and the surface of the flesh is dried. The processes also strengthen the skin of the fish and equalize the fat content. Immediately after being fried in oil, the fish are washed thoroughly in hot water. Then they are cooled for about 20 hours. After being cooled the fish are packed in cans. All fish should be uniform in size. For sardines, round-herring and anchovy, code marks for the number of fish must be embossed on the top of the can as follows:

About 75 g of boiled tomato puree (specific gravity 1.04) is added, and the cans are sealed. The packed cans are washed in hot soapy water before they are sterilized in a retort for 80～90 minutes at 240°F (115°C) is maintained. After being sterilized and cooled, cans are wiped, labelled and packed in wooden boxes or cartons.

Table 4-23. Number of fish according to size, in each size of cans

Size of can	Mark			
	G	L	M	S
No. 4 tall can	——	Max 12	13-20	Min 21
No. 1 oval 〃	Max 8	9-12	13-20	Min 21
No. 3 oval 〃	Max 8	9-12	Min 13	——
No. 1 small	——	Max 6		——

The color of tomato puree used in Japanese tomato sardines has hitherto been unsatisfactory, and has constituted an outstanding defect of the product. An appreciable improvement has been made with the importation of Italian tomato paste since 1932, and of American paste since 1946. American tomato paste is diluted with Japanese tomato paste to attain desired color. On the other hand, efforts are being made by those who are concerned with the industry to improve the quality of the domestic tomato. In view of this fact, it is expected that tomato puree of good quality will be produced in this country in the near future. The net contents of tomato sardine cans should be 425 g for No. 4 tall can and No. 1 oval cans, 215 g for No. 3 oval can, and 155 g for No. 1 small cans.

b. Raw pack method

Heads and viscera of fresh sardines are removed as in the case of the fry cooking method. The fish are then packed in cans after being soaked in Bé 18～20° brine and washed with water without drying. The cans are then cooked sufficiently in an exhaust box, so that some of the water contained in the fish is removed. After addition of some heated tomato puree having some what greater density (sp. gr. 1.045-1.050), the cans are sealed and sterilized as in the case of oil cooked sardines.

2. Oil sardines

About 38 g of fresh sardines is used for a can oil sardine. After wasing off the blood and sand in running sea water, the heads and viscera of the fish are carefully removed. The fish are then washed again in clean fresh water. This washing must be done quickly. The fish are then soaked in a salt solution of Bé 15°~20° for about 30 minutes and are washed again in fresh water so that surface salt on the fish may be partially removed. Then the fish are placed on a shallow wire basket, in which they are left to drain for about an hour. These fish are fried for 3-4 minutes in boiling cotton-seed oil, olive oil or peanut oil which is kept at temperature of 220° to 239°F (104° to 115°C). This frying oil must be fresh and as pure as possible, with very a low acid value, so that it will not impart an unpleasant odor to the finished product. Following these steps, about 1 cm of each end of the fish are cut off with a pair of sharp scissors to secure a uniform length. The number packed in a quarter can (1/4 kg) ranges from 6 to 12, according to the size of the fish. After the fish are packed in the cans, olive oil or cotton-seed oil is added, and the cans are sealed. The quantity of oil for a quarter can (1/4 kg) is about 38 g. The cans are sterilized in a retort for 60 minutes at 220°F (104°C). It may be mentioned that some of the canners, in order to improve the flavor add a quantity of laurel leaf to the can before sealing.

3. Boiled sardines

Boiled sardines are mainly exported. This product is not very popular for domestic consumption. In the preparation of canned boiled sardine, dehydration of the fish body must be carried out. In the canning of boiled sardine; in order to dehydrate, sun-drying and drying in a drier or raw pack method (steam dehydration method) are employed as well as in the case of the preparation of canned sardines in oil or tomato sauce. Among them the raw packing method is the most popular, because the procedure is simple and fitted to mass production. Before dehydration, the heads of fresh sardines are cut off and the viscera are removed from the cut end. The blood and other substances are washed off in running sea water. Then the fish is soaked in brine of Bé 5° at 10°C, for 30 minutes to 1 hour. The brined fish is packed in cans (No. 4 can) and heated for 15 minutes at 100°C. The water exuded from the fish is removed by draining the cans. They are then sealed and processed for 60 minutes at 235°F (113°C, 8.5 1b-pressure).

4. Seasoned sardines

Canned seasoned sardine is consumed in the domestic market. The procedures are the same as those for the canned boiled sardine up to the point of filling. The seasoning material which is made from soybean sauce ("shoyu") and sugar, is put into the cans in which the dehydated sardines have been packed. The succeeding procedures are the same as those for the canned sardine in oil or tomato sauce.

5. Seasoned sardine with vegetables

To canned seasoned sardine, vegetables (e.g. soy-beans, laminaria, etc.) are often added for domestic consumption.

III. Technical Problems in Sardine Canning

1. Common problems

a. Treatment of raw sardines

Sardines are often caught abundantly at one time, and there is a need to develope improved chilling methods for large quantity of fish. When the raw sardine has high fat content which is subject to oxidation, some antioxidants (e.g. BHT, BHA) should be employed. If it is desired to preserve raw sardine for a long time, they should be ice-glazed after freezing, or frozen in packages which prevent contact with the air.

Sardines must be handled more carefully as a raw material than other fish, because their texture is soft and is easy cracked, or skinned. Sardines also readily decompose, especially in the summer. Sometimes if they are dried or salted during warm and cloudy weather, a bitter substance is formed in the meat. This substance has been found to be histamine.(48) The viscera must be completely removed from raw material for canned sardine, otherwise the canned product may be sandy.

b. Dehydration of sardine meat

It is important to dehydrate the sardine meat in order to increase its firmness, because the meat is soft, and becomes misshapen with passage of time after processing.

There are several methods of dehydration as mentioned above, viz., drying (sunshine or by a drier), roasting, frying, and steaming (raw packing). If the meat is dehydrated by roasting, frying or sun drying, it may smell rancid. The meat of canned sardines processed by steaming does not smell rancid, but its texture becomes quite soft. Each method has its respective merits and faults. It is important in processing to employ the right method remembering that it influences the quality of the finished products, as well as the expense and the production capacity.

Shimoi, Noguchi and Oiwa(49) have studied the relation between the quality of canned sardines and the method of dehydration (drying and steaming methods) and came to the following conclusions: (1) Appearance: There was no difference between the finished product prepared by the two methods; (2) Shape and lustre: The shape and lustre of the finished product prepared by drying method were better than those made by raw packing (steaming) method. Skinning was less in the former method but in the latter the skin came off in places, and it had no lustre; (3) Cracking of the meat: With the former method, there was almost no cracking, but in the latter there was some cracking in over a half the fish; (4) Hardness and color: In the former, the hardness was better and the color of the meat was yellow; but in the latter the meat was soft, but elastic, and its color was white. On a basis of quality the latter was better than the former; (5) Vacuum: There was no difference between the two methods. This rather depended on the amount of solid meat; (6) Proportion of the solid meat juice: The amount of the solid meat of the former was much higher than that of the latter. On the contrary, the amount of juice of the former was less than that of the latter; (7) Appearance of the juice: The juice of the former was transparent, but that of the latter was rather turbid. The amount of floating oil in the juice of the former was less than that of the latter. (8) Moisture-content of meat: The former contained less water than the latter. (9) Amount of solid matter in the juice: The amount of solid matter was less in the former than in the latter; (10) Color and acid value of floating oil in the cans: Oil in cans made by the drying method where material was easily oxidized during the drying showed high acid values and reddish color. The acid value of the former was 1.2 and that of the latter was 0.8.

In conclusion, the finished products prepared by the raw packing method was inferior in appearance because of skinning and cracking of the meat, but the firmness, color and texture of the meat were better and the acid value of oil separated from the juice was lower. If the skinning and cracking of the meat can be prevented, the raw packing method is preferable, because of economy and production capacity.

c. Processing

Canned sardine must be sterilized in a retort at high temperature in order to soften the bones. If the temperature is too high, the texture of the meat will be come soft. Therefore it must be processed at adequate low limit temperature, and for that reason there must be a rigid enforcement of regulations to maintain a high degree of cleanliness in the factory.

2. Problems concerning the canned sardine in tomato

a. Quality

The quality of raw sardines is based on size, freshness and amounts of chemical components.

For canned tomato sardine it is desirable to use large fish (above 16 cm). However, this size of sardine lacks uniformity and presents difficulties during packing. For example, according to the size of the fish, the can-size must be selected. Even if the can-size is definite, the number of the fish will vary. Generally the can-size used for tomato sardine is the oval 1 pound can (oval No. 1 can) or a half pound (oval No. 3 can). In the case of using 1 pound-oval can, if 9-12 bodies of sardine are packed, it is called L-size (Large size) ; if 13-20 bodies are packed, it is called M-size (Medium size) and if above 21 bodies are packed, it is called S-size (Small size). Because large size raw sardines are used for canned tomato sardine, it is difficult to obtain uniform salt (NaCI) penetrate into the body during this step. Also heat does not easily penetrate into the contents during processing. Nagatake(50) has studied in detail the relation between the size and the penetrations of salt and heat during the processing. The freshness of the raw sardine influences the quality of canned product.

According to the results obtained by Hokkaido Fisheries Experimental Station,[61] the limit of freshness should be below 30 mg % of volatile basic nitrogen. The amount of fat in raw sardine also influences the quality of the finished product. Generally, unless raw sardines containing 15 % or more of fat are packed, a good quality product cannot be obtained. According to Wada[62], the amount of fat in sardine caught in Kyushu, where a great amount of canned tomato sardine is processed, is 10-15 % in December to February, about 5 % in March to April and about 10 % in May to June.

Therefore the material must be treated appropriately according to the fishing season.

b. Heat penetration during processing

Canned tomato sardine is characterized by a slow rate of heat penetration because of the added tomato sauce. In fact, the temperatures in No. 1 oval cans (1 pound content) and No. 3 oval can (a half pound) are delayed in reaching the temperature of the retort by 60 and 30 minutes, respectively, as shown in Fig. 4-8. In order to accelerate the processing time, many devices have been employed.

For example, according to the Japanese Canners' Association[63], the temperature of the retort was raised to 15 1bs-pressure in the initial period of the processing time at 10 lbs pressure in order to rapidly bring up the temperature at the center of the cans, this procedure was not particularly effective. This problem requires consideration.

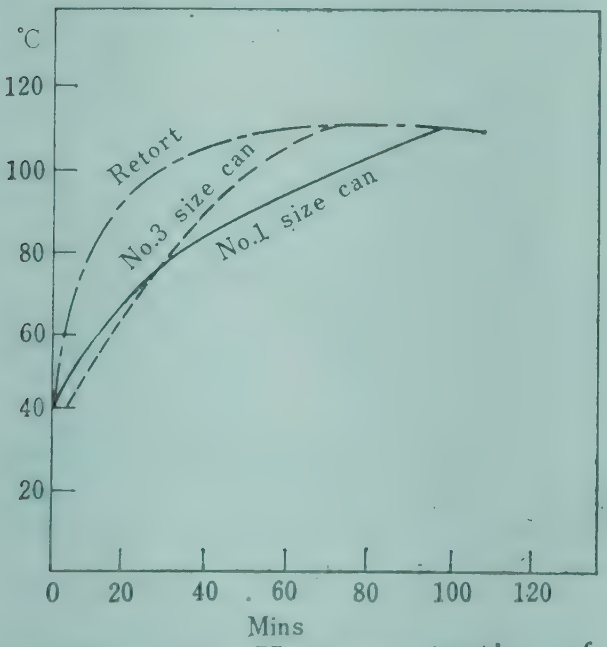

Fig. 4-8. Heat penetration of canned tomato sardine

c. Swelling after processing

When the cans of tomato sardine are taken from the retort after processing, they often swell. According to Ishida et al.[64], the cause may be due to the fact that if the heated cans are immediately cooled, the inner pressure of the cans becomes larger than the external pressure. In order to prevent such swelling, the pressure cooling should be employed.

d. Low vacuum

When canned tomato sardines are transported to the Philippines or the South Sea Islands, their vacuum will decrease. This is due to the change of temperature after the processing. For example, the vacuum of the canned tomato sardine goes down about 2 inches per each 10°C temperature rise (Shimoi and Noguchi(55)). In order to retain a high vacuum in canned tomato sardines, Umemiya(56) has offered the following suggestions: (1) A uniform and adequate fill in weight should be used, (2) The tomato sauce should be added at a temperature above 80°C, (3) After adding tomato sauce, the can should be sealed as quickly as possible, (4) After the processing cans should be cooled as rapidly as possible.

e. Properties of tomato sauce

Japanese tomatoes ("Aichi" species) is suitable for fresh eating, but not suitable for canning. This is true because, when the tomato puree, of which the color is dark or yellowish brown after preparation, is added to fish and processed, the color fades. In Japan the tomato puree to be added is prepared from Japanese tomato puree mixed with American tomato puree. On the other hand, various kinds of tomato which are getting acclimatized and becoming suitable for canning (e.g. Marglobe, Shonbare, Sun Ozecanner or Norton etc.) are being cultivated at present. The tests for tomato puree are carried on by the same method as those prescribed by U.S. Food and Drug Administration.

Tomato puree added to the canned tomato sardine is separated to solid and liquid portions during heat processing or in storing the can. Recent study provided a method to prevent the separation of tomato puree components by adding with a certain of polysaccharide at 0.2% concentration.

3. Problems concerning canned oil sardines

a. Presence of lead

Abnormal amounts of lead have sometimes been found in canned sardine in oil which are made not only in Japan, but also in Spain or

Portugal or the U.S.A. The lead content is restricted to below 2.6 ppm according to U.S. Food and Drug Administration. According to the Japanese Canners' Association[68], the presence of lead is caused more often by frying oil or frying equipment than the solution of lead from solder of the can container. Therefore in Japan canned sardines in oil are mainly made by the raw packing method (steaming method).

b. Reddening of added oil

In canned sardine in oil, the added oil sometimes reddens during a long period of storage after processing. This phenomenon has been found in cans which were made not only in Japan but also in France. According to Hirano and Ono[69], the cause of the reddening is due to the fact that the frying oil was used too much or to the characteristic properties of the meat of sardines meat which have eaten Copepoda. They proposed the following preventive procedures: (1) Fresh raw material should be used, from which viscera should be completely removed; (2) All the procedures should be completed in short time; (3) The frying oil should not use too long; and (4) Cool the cans as quickly as possible.

4. Problems concerning canned boiled sardines

a. Browning of the juice

It is sometimes found that the color of juice of canned boiled sardine changes to a heavy brown. Suenaga et al.[48] have demonstrated that the browning of the juice is caused by the coloring matter dis-solved out from muscle tissue during prolonged storage of the canned product.

SAURY-CANNING INDUSTRY

I. Saury Fishery in Japan

Saury ("sanma", *Cololabis saira*) is sometimes called mackerel pike. Because of the decrease of sardine, saury is now used extensively for canning. The body of saury is quite elongated and somewhat compressed. Its color is blackish blue above and silvery white below. It attains a total length of 30 cm or more. Saury is a cold-water fish, which is widely distributed from Shimushiru of the Kurile Islands to the Goto Islands of Kyushu in Japan. The spawning season is October to December on the Pacific Coast, and in May to August in Goto, Tsushima, Oki, Sado Islands and in Korea. The temperature of the sea water during the fishing of this species is 12° to 20°C; at 17.5°C the fishing is the best. The migration of this fish is controlled by the cold current running southward. It is usually caught in "stick-held dip net". This fish is very delicious when roasted with salt.

The total amounts of saury caught for the years 1954 to 1968 are shown in Table 4-24.

Table 4-24. Variation of saury catches in Japan (1954-1968)

Year	Catch (1,000 metric tons)	Year	Catch (1,000 metric tons)
1954	284	1963	384
1955	489	1964	210
1956	314	1965	231
1957	408	1966	241
1958	575	1967	220
1959	523	1968	140
1960	287		
1961	473		
1962	483		

The catch in 1958 was slightly over 575 thousand metric tons, which was the largest to date.

II. Canning of Saury

1. Kinds of canned saury

Saury has been caught instead of the sardine as the catch of the latter decreased. The kinds of canned-saury are almost the same as those of canned sardines, and comprise canned boiled saury, canned saury-fillet in oil, canned saury in tomato sauce, canned seasoned saury, canned seasoned saury-fillet, canned roasted saury ("kabayaki") and others.

2. Production of canned saury

The production of various kinds of canned saury in 1968 is shown in Table 4-25. Boiled saury is packed principally in No. 4 tall cans (4 dozen in a case) and in small No. 1 cans (100 cans in a case). Canned saury in tomato is packed principally in oval cans of various net contents. Seasoned saury is packed principally in No. 5 cans and No. 6 cans (one case contains respective 4 dozen of cans). Saury in oil and roasted saury ("kabayaki") are packed in square cans of various net contents.

Table 4-25. Production of canned saury in 1968

Kinds	Real no. of cases	Converted no. of cases
Boiled saury	23,024	16,043
Saury in tomato	4,072	1,945
Seasoned saury	546,352	254,936
Saury in oil	27,604	11,851
Roasted saury ("kabayaki")	916,740	223,017
Total	1,517,792	507,792

3. Export of canned saury

Among various kinds of canned saury, there is an export market for canned tomato saury, canned oil saury and canned boiled saury. The amounts of canned saury exported and principal export countries (above 1,000 c/s) in 1969 are shown in Table 4-26.

Table 4-26. Exports of canned saury in 1969

Kinds	Real no. of cases	Principal destinations
Boiled saury	1,053	New Guinea
Converted no of cases	852	
Saury in tomato	6,962	Burma, Singapore, Malaya, Philippine, New Guinea, Pacific, Ocean islands,
Converted no. of cases	6,576	
Saury in oil	32,103	Philippine, Ceylon, Holland, Belgium, West Germany, Swiss, Italy, Greece, East Africa

Kinds	Real no. of cases	Principal destinations
Converted no. of cases		
Total	49,242	
Converted no of cases	18,691	

4. Canning

The method of canning saury are almost the same as those for canned sardines. There are some kinds of canned saury, viz., canned boiled saury, and saury in oil, or tomato sauce for which the initial treatments (washing, salting, dehydrating, and packing) are almost the same as for sardines before the additions of oil or tomato sauce.

The dehydration is usually carried out by raw packing method (steaming method).

a. Treatment of fresh or frozen saury

(1) Fresh saury

When landed the fish are weighed into a basket(content 75 kg), and transported to the cannery. The fish are then transferred into flat boxes on which crushed ice is placed. The boxes are piled one upon another. Sometimes fish are soaked in ice water containing salt in a tank (wooden or concrete). Though it is not uniform, according to room temperature, about 325 kg of ice and 10 kg of salt are employed for 1,000 kg of fish in order to maintain freshness. The fish, crushed ice and salt are piled upon each another in the tank. The tank is then filled with cold water covered with a straw-mat. Sometimes, fish from which heads have been removed, are cut and soaked in a tank of ice water.

(2) Frozen saury

It is better to thaw frozen saury in air than in water. When partially thawed, the individual fish are removed from the frozen cake. If they are thawed completaly, the bodies become too soft for handling.

b. Cutting

The head is cut from the body, and the visceral mass is removed completely. The cut end should be straight. The fish are then washed.

The bodies are cut into two or three pieces depending upon the size of cans being packed. According to the export regulations of the Japanese Canned Foods Inspection Association, inside enamelled cans must be used, units should be similar in size, and the maximum content of No. 1 small cans (175.7 g content) shall be 7 pieces.

c. Salting

Out fish bodies are soaked in Bé 18°～20° brine for 20～40 minutes. In hot weather, sometimes ice blocks are put into the brine. After salting, the fish bodies are quickly washed.

d. Packing

The washed saury bodies are weighed. The net contents vary according to can size: for No. 4 tall cans, 425 g; for No. 1 oval cans, 425 g, for No. 3 oval cans, 215 g; for No. 1 small cans, 155 g; for No. 3 B square cans, 105 g; for No. 5 A square cans, 110 g, for No. 8 square cans, 227 g; and for No. 9 square cans, 225 g. The packing shall be carried on in a manner to present a good appearance.

e. Steaming

In the raw packing method, the packed cans are cooked in a retort with steam at 212°～218°F (100～103°C) for 30～50 minutes. After the steaming, the free liquid is drained by inverting the cans. After the draining, the cans are cooled.

f. Addition of tomato sauce or oil

Canned tomato saury is prepared by packing dehydrated saury with tomato and oil is added in the case of canned oil saury.

g. Exhausting and sealing

The packed cans are sealed after steam exhausting in an exhaust box or are sealed immediately by means of a vacuum seamer without prior exhausting.

h. Processing

The processing temperature and time for canned tomato saury vary according to the can-size as shown in Table 4-27. Data on processing of canned oil saury are shown in Table 4-28.

III. Saury-fillet in Oil

After dehydration of saury in a basket by steaming and draining as that in the processing of canned boiled saury, the body is split in two to remove the back bone, and the fillets are prepared. The fillets are packed in square cans and oil is added after which the cans are sealed and processed.

Table 4-27. Processing temperature and time of canned tomato saury

Can-size	Processing temp. (°F) (°C)	Processing time (mins.)
No 4 tall can	235~240 (112.6~115.8)	90~110
No. 1 oval can	235~240 (112.6~115.8)	90~110
No. 3 oval can	235~237 (112.6~114.0)	85~100
No. 1 small can	232~240 (111.3~115.8)	70~90
No. 8 square can	235 (112.6)	100

Table 4-28. Processing temperature and time for canned oil saury

Kinds	Can-size	Processing temp. (°F) (°C)	Processing time (mins.)
Canned saury in oil	No. 3 oval can	237 (114.0)	80
	No. 5A square can	232 (111.3)	90
	No. 8 square can	237 (114.0)	80
Canned saury fillet in oil	No. 5A square	232~234 (111.3~112.6)	75~80
Canned smoked saury in oil	No. 3B square can	228 (109.0)	60

IV. Smoked Saury

Saury are dry-salted after removal of the head. After salting, they are desalted in water. After draining, they are smoked by the cold smoking method. The smoked saury boides are packed in cans with oil, then sealed, and processed as usual.

V. Technical Problems in the Processing of Canned Saury

1. **Limit of freshness of saury as raw material for canning**

The meat of saury is soft, and its rate of decomposition is rapid as in the case of the sardine.

Tanikawa et al.(60) have studied the limits of freshness of saury as raw material for canning. According to their results, the limit of freshness of saury meat for canned boiled saury is 20 mg% of volatile basic nitrogen, and 25 mg% when canned with tomato sauce. Tomato sauce will mask a slight stale odor in saury.

TUNA-CANNING INDUSTRY

I. Annual Catch of Tuna

The annual catch of tuna by Japanese fishing boats including albacore (or longfin tuna; *Germo germo*), blue fin (or tunny fish; *Thunnus thynnus*), yellow fin (*Neothynnus macropterus*), big eye tuna (*Parathynus sibi*), striped tuna (skipjack; *Katsuwonus pelamis*) and other varieties, are show in Table 4-29.

Table 4-29. Annual catch of tunas (1,000 tons)

Year	Blue fin tuna	Albacore	Big eye tuna	Yellow fin tuna	Skip jack and Bonito
1958	21	63	72	111	144
1959	51	68	74	126	166
1960	65	89	72	154	78
1961	70	87	113	148	144
1962	46	104	126	158	170

II. Varieties of Tuna used for Canning

Varieties which are now being used in Japan as raw material by the una-canning industry are albacore, yellow fin and others. Canned tuna nade with albacore is called "white meat tuna," and the products made vith other tuna are called "light meat tuna". Among the tuna, albacore s almost entirely used for canning.

III. Fishing Grounds and Fishing Seasons

The tuna fishing grounds are in the Pacific Ocean where the fishing oats operate from ports in Japan, and in other Oceans to which Japanese ising boats travel from ports in foreign countries. Tuna long-line ishing, which has been carried on in the South Pacific Ocean (since 1955) and the Atlantic Ocean (since 1957), from ports of foreign ountries is supported by individual Japanese enterprises or by joint nterprises with foreign concerns.

Blue fin tuna are found in sea water of which the temperature is 14° ~20°C. They are caught off the coast of Japan in the summer and autumn.

Albacore are caught in the seas, around 26~30° N Lat: 135~175°E Longt. from the middle of May to the middle of June. In the winter the principal fishing grounds are to the north and east of Midway Island.

Yellow fin tuna are caught mainly in seas around the equator, in the southern Pacific Ocean, and Indian Ocean. They are also caught near the lower California in July-August, and in the Pacific Ocean near Japan from May to October.

Big eye tuna are widely distributed and are caught from the equator to Lat. 40°N. They are found together with albacore and yellow fin tuna.

Striped tuna (skipjack) are only caught by pole and line fishing methods. They are caught throughout the year in the seas surrounding Japan.

IV. Fishing Methods

The methods used in fishing for albacore are mainly long line fishing (hook and line fishing) and also pole and line fishing (angling or hand-line fishing). Albacore and striped tuna are often fished by the same boats, and consequently, in the spring and summer seasons, the pole and line fishing method is mostly used. In the winter albacore is fished by long line fishing, as the fish do not swim near the surface. Other tuna are also fished by long line fishing.

When a tuna vessel using the pole and line method, sights a school of tuna live bait such as small sardines, pilchards, or anchovies are thrown overboard from the bait tank. Fishermen stand on a specially designed rack and fish with lines and barbless hooks. There are two kinds of hooks. One is made for attaching live bait, and the other is made in the form of a lure, called a "jig". When the tuna take the hook, they are pulled on board by means of a heavy pole and are released from the barbless hook as soon as they land on deck.

In the case of use of the long line fishing method, when the tuna vessel reaches a fishing ground, a long line having hooks is cast into the sea for 3～4 hours. The hooks are baited with frozen or salted sardines, squid, or saury. After the lines are cast, the vessel remains in position for 3～4 hours before hauling in the line. It requires 13～14 hours for a line-hauler to bring in a line.

The fish are landed on the deck and are carried through deck plates into the fish-hold in which they are chilled by means of crushed ice, or in chilled brine in tanks. When the fish have been chilled to the brine temperature, the warmed brine is pumped overboard. The fish are then completely frozen by refrigeration coils located in the tanks. They are held frozen until landed at the canning plant.

V. History of Tuna Canning

Canned tuna in oil was first experimentally put up in 1906, and by about 1919 the annual production had reached 3,000 to 4,000 cases. At is time the industry suspended operations because of a lack of demand r canned tuna. In 1926, however, with the decrease in the American bacore catch, experimental exports of frozen albacore to the U. S. A. ere made. On the other hand, canned tuna in oil was prepared expernentally on a small scale by the Fisheries Experimental Stations of hizuoka, Chiba and Kochi Prefectures in 1926~27. These experimental roducts were sent to the U. S. A. and when a good prospect of business as assured, the experimental stations encouraged and guided private nterprises in producing canned tuna in oil. Thus, in 1930, a tuna annery was established at the city of Shimizu, Shizuoka Prefecture, and did a fair business. In 1931, there were five canneries in the country, roducing 28,000 cases of canned tuna. In the following year (1932) he industry made a rapid advance, and the number of canning plants as increased to sixteen. New enterprises were also planned for 1933 ecause of the growing prosperity of industry. At present the total nnual production including all kinds of canned tuna is about 7 million ases, of which about 3.7 million cases are exported to foreign countries.

VI. Kinds and Production of Canned Tuna

Canned tuna is prepared in many forms, such as tuna in brine, in oil, easoned tuna with or without vegetables. Flake meat is canned as well s solid meat. Production statistics for canned tuna in 1968 are shown n Table 4-30.

Table 4-30. Production of canned tuna in 1968

Kinds	Real no. of cases	Converted no. of cases (one 48 lb case)
Tuna in brine (white meat)	1,502,953	691,128
Tuna flake meat in brine (white meat)	10,568	5,362
Tuna in oil (white meat)	415,047	151,849
Tuna flake meat in oil (white meat)	142,457	49,397
Tuna in brine (light meat)	591,461	272,506
Tuna flake in brine (light meat)	16,906	8,133
Tuna in oil (light meat)	1,627,978	608,106
Tuna flake in oil (light meat)	92,230	28,484
Seasoned tuna meat	341,374	163,969

Kinds	Real no. of cases	Converted no. of cases (one 48 lb case)
Seasoned tuna flake meat	509,456	258,637
Tuna in Jelly	45,778	18,320
Others	942,782	378,286
Total	6,238,990	2,634,177

Tunas are packed principally in tuna No. 1 can (1 lb), No. 2 can (a half lb), and Tuna 2 K can. One case contains 2 dozen for No. 1 can, 4 dozen for No. 2 can, and 6 cans for Tuna 2 K can.

VII. Exports of Canned Tuna

Among various kinds of tuna, canned tuna in oil and in brine are exported as shown in Table 4-31.

Table 4-31. Exports of canned tuna in 1969

Kinds	Realt no. of cases	Converted no. of cases	Destination
Tuna in brine (white meat)	2,499,965	1,154,488	U.S.A., Canada, Holland, Europe, Okinawa
Tuna in brine (light meat)	621,449	294,045	U.S.A., Belgium, West Germany, U.K., Swiss, Pacific Ocean Islands
Tuna in oil (white meat)	434,448	181,715	Canada, Middle America, West Indias, Holland, Belgium, France, West Germany, Sweden, Swiss, West Africa, East Africa, Lebanon, Mid-East, Okinawa
Tuna in oil (light meat)	2,204,232	781,528	Canada, South America, Middle America, West Indias, Europe, U.K., Sweden, Ireland, Swiss, West Africa, East Africa, Lebanon
Others	1,361,389	556,935	Australia, New Zealand, Hong Kong, South East Asia, Philippines, Mid-East, Lebanon, U.S.A., Canada, U.K., Europe
Total	7,121,483	2,968,711	

VIII. Canning Districts and Seasons

The important tuna canning districts are Shizuoka, Kanagawa, Chiba, iyagi, Iwate, and Kagoshima Prefectures, because of their locations ear the fishing grounds. In 1931 there were only five factories including hose established in Shizuoka, Miyagi and Chiba Prefectures, but since hen the number has rapidly increased. Today there are about 60 actories in Shizuoka Prefecture alone, and when those in other prefectures re added, the total amounts to over 200 factories. Canning seasons ary according to district. In Shizuoka and Kanagawa Prefectures, from he beginning of January to the end of March is the first canning season. n April tuna fishing is suspended. Fishing and canning are the carried n from the beginning of May to the first part of July, the early part f June being the most active canning season. In the Miyagi district, he season comes slightly later than in the Shizuoka district, being from une to August, the middle of July constituting the busiest period.

IX. Processing of Canned Tuna in Oil or Brine

The fish to be used as raw material for packing must be as fresh as ossible and should be free from any damage. When the fresh fish are rought to the factory, the heads are first cut off, then the viscera are emoved, and the fish are thoroughly cleaned and washed. They are hen steamed as described below for frozen fish. If frozen, the fish are irst placed in water for about 20 hours, and when thoroughly thawed re steamed. The temperature and period of steaming differ according o factories, but generally the fish are steamed until all parts are ompletely cooked. On the average, the steaming process lasts for three o four hours at a temperature of 220°F (104°C).

The steamed fish are then placed in cooking racks in a well-ventilated oom until the next morning. Then they are placed on cleaning tables, here bones, scales and inedible parts are removed, leaving only clean hite meat. The yield of usable meat amounts to approximately 40%.

The white meat is then cut into proper sizes by hand or automatic cutters, and packed into cans. There are four methods of packing: viz. solid pack, standard pack, belly meat pack and flake pack. "Solid pack" consists of a piece of meat in one can; "Flake pack", flakes only in one can, "Belly pack", belly meat only in one can. After the cans are filled, a good quality cotton seed or olive oil and refined salt are added. When "canned tuna in brine" is prepared, 5 % NaCl solution is added instead of oil. The volume of oil added varies according to the size of cans, for example in No. 2 cans, 30 g of cotton seed or olive oil and 4 g of refined salt are added.

The inside of the can is C-enameled in order to prevent the formation of iron sulfide as an effect of sulfur liberated from the meat. The filled cans are vacuum sealed and washed by means of a "can-washer", and sterilized in a retort. The processing time and temperature for canned tuna are shown in Table 4-32.

The sterilized cans are cleaned by pass in, through a tank of alkaline washing solution followed by passage through a cold water cooling tank. They are then inspected, labelled, and packed in cases

X. Seasoned Tuna with or without Vegetables

Waste meat of all the kinds of tuna including skipjack which means chips of solid meat is used for processing into "canned seasoned tuna". Bones in the waste meat must be completely removed. The refined waste meat is crumbled into flakes. A definite weight of flake meat is packed into cans, and seasoning juice is added. The cans are processed as in the usual manner. Sometimes, seasoned vegetables, especially prepared bamboo shoots are added to the tuna meat.

Solid tuna meat in cubes is often seasoned and processed. This is called "Kakuni". To prepare canned "Kakuni", solid tuna meat is cut into cubes of 1.5 cm size which are then boiled in water for 3～4 minutes. After boiling, the cubes are removed from the water and drained. They are then held in seasoning juice for 2-3 hours, packed in cans, and processed as usual.

To prepare canned "Teriyaki", skipjack meat is cut into flat rectangular pieces. This meat is roasted over a charcoal fire until completely cooked.

Table 4-32. Processing time and temperatures for canned tuna

Kind	Can-size	Weight of solid meat (g)	Total weight of content (g)	Processing temp. °F (°C)	Processing time (min.)
Tuna in oil	Tuna No.1 can	310	370	232~236(111~113)	70~90
	〃 No.2 〃	165	200	232~235(111~112)	70~80
	〃 No.3 〃	80	100	Ditto	60~90
	〃 2kg 〃	1,530	1,880	232~236(111~113)	180
	〃 2.5kg 〃	1,770	2,170	235(112)(8.0 *lb*)	180~220
Skipjack in oil	Tuna No.1 can	310	370	235(112)(8.0 *lb*)	85~90
	〃 No.2 〃	165	200	231~236(110~113)	70~80
	〃 No.3 〃	80	100	232~235(111~112)	60~70
	〃 2kg 〃	1,530	1,880	235~236(112~113)	170~180
	〃 2.5kg 〃	1,770	2,170	235(112)	180~220
Tuna flake in oil	Tuna No.1 can		340	235(112)	95
	〃 No.2 〃		185	235(112)	90
	〃 2kg 〃		1,705	235(112)	180
Skipjack flake in oil	Tuna No.2 can		185	233(112)	190
	〃 2.5kg 〃		2,000	235~240(112~115)	180~190
Tuna in brine	Tuna No.2 can	165	200	233~235(111~112)	70~90
	〃 No.3 〃	80	100	Ditto	60~90
	〃 1kg 〃	680	900	Ditto	70~130
	〃 2kg 〃	1,530	1,880	Ditto	180~210
	〃 2.5kg 〃	1,770	2,170	Ditto	210~220
Skipjack in brine	No.4 can	350	425	235(112)	100
	Tuna No.1 can	310	370	Ditto	80~90
	〃 No.2 〃	165	200	232~235(111~112)	70~90
	〃 No.3 〃	80	100	Ditto	60~70
	〃 2kg 〃	1,530	1,880	235(112)	170~185
	〃 2.5kg 〃	1,770	2,170	Ditto	180~210
Tuna flake in brine	Flat No.2 can		185	235(112)	90
	Tuna 2kg		1,705	Ditto	180~190
Skipjack flake in brine	Tuna No.1 can		340	Ditto	95
	〃 No.2 〃		185	Ditto	90
	〃 2kg 〃		1,705	Ditto	180
	〃 2.5kg 〃		2,000	Ditto	180~210

After the roasting, the meat is soaked in the seasoning juice and is then roasted again. The alternate roasting and seasoning are repeated several times. The seasoning juice consists of soy bean sauce ("shoyu") (1.8 litre), sugar (0.3～0.5 kg) and water (1 litre), sometimes sweet "sake" or millet-jelly are added. The canned seasoned tuna is consumed by domestic market.

XI. Technical Problems

Because of its importance, many technical problem concerning the processing of canned tuna have been studied in Japan.

1. Effect of fishing methods on raw material

As noted above the principal fishing methods used by Japanese fishing vessels for catching tuna are long line fishing and pole and line fishing. Hasegawa and Fukao(61) have studied the differences in tuna which are caught by these two fishing methods. According to their findings, there are almost no differences between them in respects to appearance, freshness, water-content, pH of the meat and the quality of the meat after steaming. More bruising of the belly meat occurs in long-line fishing than in pole and line fishing.

2. Effect of handling methods on fishing vessels on quality

Shimoda(62) has studied the variation in freshness of tuna meat caught at the same time and loaded by piling the fish and ice in several layers in the same fish-hold layer by layer. According to his observations, there is no difference between fish which were piled in the upper, middle or lower layers. However, if the water which drains from the fish is not removed from the bottom of the tank, the freshness of tuna piled in the lower layer decreases rapidly.

3. Preservation of raw skipjack after unloading at the cannery

When fresh raw tuna is unload at the cannery, and the method of preservation is not suitable, there is a rapid loss of fresh quality.
Sumino et al.(63) have studied the preservation of raw skipjack by the

use of crushed ice and by the ice water. According to their findings skipjack preserved by crushed ice was better in quality for canning that held in ice water.

4. Steaming fresh raw tuna

In the processing of "canned tuna in oil" or "in brine" it is important to dehydrate meat by steaming the fish body. Steaming of the tuna body is carried on in a retort at 218°F (103.6°C, 2·1b-pressure) for 4.5 hours, after the head and visceral mass have been removed. The purpose of steaming is to coagulate the fish meat protein and to increase firmness through partial dehydration. The conditions of the tuna fish after steaming influenced the efficiency of succeeding steps of preparation, and the quality and yield. Many investigators have studied various problems related to steaming. Hasegawa(64) has stated the weight of the steamed tuna body should become 70～80 % of the weight of the raw body as a result of dehydration. When frozen tuna, the steaming time should be increased. Taneishi(65) has devised an equation for calculating the steaming time of skipjack to reach an adequate degree of firmness and dehydration. He found that the maximum yield was obtained when the center of the fish reached a temperature of 80°～83°C. The steaming time should be decreased when very fresh raw material is used.

Yoshino(66) has studied the changes of temperature in the center of fish body and the weight and firmness during both steaming and cooling after the steaming. He reported that the temperature in the center of the fish should be 70°C for canned tuna in brine, and 65°～70°C for the canned tuna in oil. He has devised equations for calculating the steaming time, cooling time, loss of weight resulting steaming or cooling, the hardness of the meat after cooling, and the loss in drained weight in canned tuna. A consolidated scale based on the weight of raw tuna body and the steaming temperature was presented.

5. Processing time

Naito(67) has studied the "f_h" and "j" values of canned tuna in various can sizes from heat penetration curves as follows:

He calculated the processing times, from the values of "f_h" and "j" and

Table 4.33. The f_h and j values of the heat penetration curves of canned tuna in various can-sizes

Can-size	$f_h \cdot k$	f_h (min.)	Coefficient of heat penetration	Processing temp.	$\frac{k+p}{2p}=j$
Tuna No. 3 can (Fancy)	1.61	24	1.14×10^{-3}	232°F	64/91.3=0.70
〃 No. 2 〃 (Fancy)	2.39	35	Ditto	〃	100/91.3=1.09
〃 No. 1 〃 (Fancy)	4.07	60	1.13×10^{-3}	〃	140/91.3=1.53
Tuna 2 kg can (Fancy)	13.3	95	(1.17×10^{-3}) 2.23×10^{-3}	235°F	180/92.7=1.94
〃 2.5kg 〃	14.8	106	(1.17×10^{-3}) 2.33×10^{-3}	〃	196/92.7=2.12
Tuna 2 kg can (Flake meat)	13.3	108	2.02×10^{-3}	235°F	130/92.7=1.40
〃 2.5kg can (Flake meat)	14.8	122	2.02×10^{-3}	〃	145/92.7=1.57

the thermal death curve of *Cl. botulinum* to be 102～114 minutes for tuna No. 2 can (fancy meat) at 110°C, and 154～160 minutes for tuna No. 1 can, 172～214 minutes for tuna 2 kg can, and 210～244 minutes for tuna No. 2 kg (flake meat).

6. Honey-comb meat in canned tuna

In 1930 honey-comb meat was found in canned tuna which was prepared from stale raw material. According to later studies(68) (69), the cause of this condition is as follows: During steaming the volume of the meat contracts with removal of water owing to the coagulation of proteins in muscle meat, and coagulation begins at the surface. When the water in the inner part of the meat evaporates and generated gases or bubbles escape through the soft not yet coagulated gelatinous parts (altered connective tissue or collagen), the gelatinous parts swell like soap-bubbles because of the pressure of gases. The swelled gelatinous parts solidify after the cooling and exhibit this honey-comb condition. Thus, even in fresh tuna meat, this condition may occur. Of course, larger masses of honey-comb can be caused by gases generated by bacterial action in poor quality raw material.

7. Blackening of tuna meat

Immediately after World War II black spots which, had not been previously observed, were occasionally seen in canned tuna. Shimoda(70) has stated that this blackening may be caused by iron sulfide from iron in the added salt and hydrogen sulfide liberated from the meat during processing. But since that time, and with the use of salt that is completely refined, this blackening has not been found.

8. Influence of acid-value of oil on can enamel

C-enameled cans are used for tuna to prevent blackening. If the acid value of the added oil is above 1.3, the inside enamel-coating will come off. Thus it is important that oil of a lower acid value be used.

9. Glass-like crystals (struvite)

Often glass-like crystals are found in canned tuna, especially brine packed, as well as in canned crab. The crystals have the following chemical formula, $MgNH_4PO_4 \cdot 6H_2O$. The formation of struvite crystals was found to be due to the slow cooling of the cans after processing (Tanikawa(34)). For detailed discussion readers are referred to his papers.

10. Heavy oil-like odor in canned seasoned tuna flake

When canned tuna flake seasoned with soya sauce is eaten, there often be found, heavy oil-like odor not remarkable but slight. Motohiro(71) have investigated the causative substance of the odor, and found that it will be contained in the unsaponificated fraction of tuna body oil. However, the reason why the substance is contained in the fish oil is not clear yet.

MACKEREL CANNING INDUSTRY

The mackerel canning industry expaned rapidly in Hokkaido after World War II. This was perhaps due to the increased amount of the catch and its high acceptable taste.

I. Kinds and Fishing Season of Mackerel

In Japan, there are two species of mackerel: *Scomber japonicus* ("honsaba", "hirasaba"), and *Scomber japeinocephalus* ("gomasaba", "marusaba"). *Scomber japonicus* are caught along the entire coast of Japan. Those caught in northern Japan are fat and have very good taste. The latter species live mixed with the former, but can not be caught in northern Japan ; their taste is inferior to that of the former. *Scomber japonicus* migrates along the coasts, while *Scomber japeinocephalus* swims far offshore. The spawning season is considered to be about April for the former and about July for the latter. For the canning industry *Scomber japonicus* is mainly used in Japan. Mackerel fishing was carried on in a small scale before World War II, by pole and line fishing, but since then fishing has been carried on by purse seine and electric light fishing on a large scale. The amount of catch reached 270 thousand metric tons in 1958. The fishing grounds and season in Japan are as follows: Spring mackerel: Kagoshima Prefecture (early in April to the end of June), Ishikawa Pref. (early in May to the end of July), Hokkaido (the end of May to middle of July) : autumn mackerel: Shimane Pref. (early October to the end of November), Iki and Tsushima Islands (middle of January to the end of March), Ishikawa Pref. (early September to the end of October), Hokkaido (the end of July to middle of October).

II. Production of Canned Mackerel

Statistics on the production of canned mackerel in 1968 are shown in Table 4-34, and it may be seen that mackerel canning is of considerable importance. Mackerel is packed principally in No.6 can and No.2 flat can. There are no specialized factor in the processing of canned mackerel and it is packed essentially as are sardines and saury.

III. Canning Districts

The mackerel canning districts are mainly Hokkaido, Aomori, Iwate, Miyagi, Chiba, Kanagawa, Shizuoka, Tottori, Shimane, Yamaguchi, Nagasaki, and Kagoshima Prefectures, because of their respective locations near the fishing grounds.

IV. Export of Canned Mackerel

Among the types of canned mackerel, boiled mackerel and that prepared in oil are mainly exported to foreign countries. The amount of export and the destinations are shown is Tablc 4-35. One-third of the total production of canned mackerel is exported.

Table 4-34. Production of canned mackerel in 1968

Kinds	Real no. of cases	Converted no. of cases
Boiled mackerel	6,714,315	4,356,864
Seasoned mackerel	1,111,435	519,898
Mackerel seasoned with "miso"	852,094	411,256
Mackerel in oil	313,204	121,015
Mackerel in tomato sauce	3,581,601	2,203,544
Mackerel roasted and seasoned	111,735	37,717
Others	21,821	12,962
Total	12,706,205	7,663,256

Table 4-35. Export of canned mackerel in 1969

Kind	Real no. of cases	Converted no. of cases	Destinations
Boiled mackerel	2,746,245	2,604,520	Belgium, West Germany, Greece, Cyprus.
Mackerel in oil	764,120	228,145	Singapore, Malaya, Philippine, Ceylon.
Mackerel in tomato sauce	3,052,953	2,197,802	New Guinea, Pacific Ocean islands.
Others	63,995	38,889	Okinawa.
Total	6,627,313	5,069,356	

V. Canning Methods

The fresh mackerel, after delivery to the cannery, are dressed by splitting, removing the head, tails, fins and viscera, followed by washing, and draining. The drained fish are cut cross-wise slices in sizes to fit the can by a machine "cutter" or by hand.

The cut pieces of fish are soaked in brine of Bé 3° for 20～30 minutes in order to extract blood. They are then soaked in brine of Bé 10°～15° brought below 10°C by use of ice in order to prevent the formation of "curd" and turbid juice, and then rinsed in fresh water and packed tightly in Flat No.1 cans (1 pound content) or Flat No.2 cans (1/2 pound content). The packed cans are weighed and vacuum sealed, and processed.

In the case of canned mackerel in oil the packed cans are inverted on wire mesh racks and cooked in retorts with live steam for 45 minutes at 3-pounds pressure. After draining for about 30 minutes the cans are reversed, and about 1/2 ounce cottonseed, olive or other vegetable oil is added. The cans are exhausted for about 10 minutes at 212°F (100°C) and then sealed: or sealed by a vacuum seamer. The sealed cans (boiled mackerel) are processed at 239°～240.5°F (115.2～115.8°C, 10-10.5 lb-pressure) for 100～120 minutes for Flat No.1 cans, 237°～240.5°F (114.9～115.8°C, 9～10.5 lb-pressure) for 90～100 minutes.

For canned mackerel fillet meat in oil, the mackerel are first brined and then filleted. The fillets are packed in oval or square cans with vegetable oil, sealed, and processed.

Canned seasoned mackerel with or without vegetables are consumed by the domestic market. In the preparation of these packs, the drained mackerel meat is packed into cans with the seasoning juice (soy bean sauce and sugar). Cooked and seasoned bamboo shoots are also added.

Canned mackerel in tomato sauce is also packed. The preparation is carried on in the same way as in the case of canned sardine in tomato sauce.

VI. Technical Problems

Tanikawa et al.(72)～(76) have studied the various problems concerning the processing of canned mackerel.

1. Limits of freshness of mackerel as material for canning

Like other canned fish, raw mackerel should be as fresh as possible for canning. The limit of freshness of raw mackerel was found to be 20 mg% of volatile basic nitrogen(73). Tanikawa et al.(74) have made a scale showing the maximum time for reaching the limit of freshness at various holding temperatures. According to this scale, if the mackerel is held at 20°C, it should be packed and processed within 15 hours.

2. Preservation of raw mackerel

Mackerel meat autolyzes more rapidly than does other fish and it caught in large amounts at one time. Therefore the use of good preservation techniques is important. There are several methods of preservation employed in Japan, ice, chilling and freezing. With ice, crushed ice and ice water methods are used. Sometimes salt (NaCl) is used with the ice. For example, crushed ice is added to brine of Bé 6° in a concrete tank and raw mackerel are soaked in this iced brine until they are consumed. This chilling temperature is considered to be best at −6°C or below. The frozen mackerel is said to readily loose its shape after processing. At any rate, the raw material should be treated carefully at low temperature.

3. Formation of "curd"

Even with fresh raw mackerel, the formation of "curd" is often found in the canned product. Such "curd" formation is due to the coagulation of soluble proteins in mackerel meat. Tanikawa et al.(75) have studied its prevention by soaking mackerel cut as steaks in brine of 10～15% NaCl to extract the soluble proteins.

4. Holding time before retorting

The cans in which mackerel meat is packed should be retorted or processed as soon as possible after being filled and sealed. Sometimes the retorting is delayed owing to an unfavourable arrangement of handling procedures. Tanikawa et al.(76) have proven by investigation that the maximum holding time of packed mackerel is within 40 minutes. If the time is prolonged, the bacterial decomposition may occur before the retorting.

HERRING-CANNING INDUSTRY

Herring which was being caught to the extent of 3.75~6.63 million tons per year was an important catch of the coastal fishery in Japan before 1935. With the succeeding decrease in the catch, the herring fishery was affected adversely. Even in the past, herring was not extensively used for canning, except for canned "migaki-nishin" which was processed for army food during World War II. Herring are mostly used for drying, salting or as raw fish.

POMPANOS (HORSE MACKEREL-)CANNING INDUSTRY

The pompanos (horse-mackerel, "aji") inhabit the warm water zone. There are two kinds: jack-mackerel ("ma-aji", *Trachurus japonicus*), and scads-like fish ("muro-aji", *Decapterus murcodsi*), which are living in the sea around Japan, from Kyushu to Hokkaido, especially to the south of the middle of Honshu. The pompanos is caught mainly in Nagasaki, Miyazaki, Yamaguchi, Shimane, Toyama and Shizuoka Prefectures. It is caught by surrounding net or stick-held dip nets. The amounts of catch of the pompanos (including jack-mackerel and scad) from 1960 to 1962 are shown in Table 4-36. The pompanos is packed principally in No. 4 tall can and oval, or square cans. The jack-mackerel and scad are used for drying, canning or are consumed as every day table food.

Table 4-36. The amounts of catch of pompanos 1960~1962

Year		1960	1961	1962
Catch	1,000 (tons)	595	542	520

I. Production of Canned Jack-Mackerel

Canned jack-mackerel has not been popular in the past, because it was used as raw fresh fish meat or for dried fish. It has certain defects, one of which is that the canned meat is too soft and another is the difficulty with which the seasoning juice penetrates into the meat during processing. But with the decrease in the catch of sardine the jack-mackerel has recently come to be used for canning. The kinds of canned jack-mackerel are that in tomato sauce of seasoned with "shoyu", or that which is boiled.

The production of various kinds of canned jack-mackerel is shown in Table 4-37.

Among canned jack-mackerel, the canned jack-mackerel in tomato sauce was exported to foreign countries (Egypt, Singapore, Malaya, etc.) to the extent of 15,703 cases in 1969.

Table 4-37. Production of canned jack-mackerel in 1968

Kinds	Real no. of cases	Converted no. of cases
In tomato sauce	274,805	181,103
Seasoned	11,432	5,334
Boiled	53,655	46,092
Others	330	237
Total	340,222	232,766

II. Canning Procedures

Canning processes using jack-mackerel are almost the same as those in preparing sardine or saury.

The dehydration of jack-mackerel meat must be dehydrated because it is soft like that of saury or sardine. This dehydration in Japan is carried out by the raw packing method (steaming method). The heads and viscera of the fish are carefully removed. The fish are soaked in a salt solution of Bé 15～20° for about 30 minutes and washed in fresh water. They are then packed in cans, which are steamed and inverted to drain. When canned boiled jack-mackerel is prepared, the cans are sealed after draining. When canned jack-mackerel in tomato sauce is prepared, the sauce is added to the fish after the steamed cans are drained. When the canned seasoned jack-mackerel is prepared, seasoning juice made from "shoyu" and sugar, is added to the fish in the can after draining.

The can sizes in which jack-mackerel is packed are restricted to the following:

Oval No. 1 can (1 lb-content)	not more than 20 fish
〃 No. 3 can (1/2 lb-content)	not more than 12 fish
Small No. 1 can (17.5 g content)	not more than 7 fish

It is not permitted to pack smaller can sizes of jack-mackerel than those above mentioned, because smaller fish are easily distorted out of shape.

III. Technical Problems

Fujiki and Nagasawa(77) have studied the chemical and physical properties of jack-mackerel meat. According to their results, the jack-mackerel meat should be dehydrated and vegetable oil added in order to attain higher nutritive value. In order to cause the seasoning juice to penetrate quickly into the fish meat, the concentration of the juice should be high. The firmness of the meat is influenced by pH, freshness, concentration of NaCl and polyphosphates. The amount of collagen in the jack-mackerel meat is less than that of other fish meat.

CANNING OF OTHER FISH

Other fish additional to those above mentioned are processed in amounts less than 50,000 cases in Japan. These fish include yellow-tail (*Seriola quinqueradiata*), sea bream (*Pagrosomus major*), cod (*Gadus macrocephalus*), etc. Among them, yellow-tail and sea bream are considered as high class material for consumption as raw fresh fish. Cod is not processed to any extent because of its bland taste. Production for these kinds of canned fish is a few.

I. Canning of Yellow-tail ("Buri")

Yellow tail meat has been liked as raw fresh fish from ancient times in Japan. When the catch of this fish is abundant at one time, some of them are packed mainly in cans seasoned with soy bean sauce("shoyu") or as canned smoked fish in oil, and seldom prepared for canned boiled fish.

The yellow-tail lives in warm sea currents. It is caught abundantly in Aomori, Chiba, Kanagawa, Kochi, Miyazaki, Niigata, Toyama, Shimane and Nagasaki Prefectures to the amount of 80,104 tons in 1968. It is fished by angling or purse seine net fishing.

1. Boiled yellow-tail

After removing head, fins and visceral mass, the fish body is filleted and cut to can-size. The cut meat is soaked in a salt solution of Bé 15° for 50 minutes. After washing with fresh water, it is packed in Flat No. 1 or Tall No. 2 cans, vacuum sealed and processed as usual. The processing temperature is held at 237°F (114°C, 9 lb-pressure) for Flat No. 1 can, or 239°F (115°C, 10 lb-pressure) for Tall No. 2 can respectively.

2. Seasoned yellow-tail

After removing head, fins and visceral mass, the body is cut lengthwise to remove the backbone. The cut meat is steamed, and roasted in a steaming basket over a wood fire. After cooling the roasted meat, it is cut according to can size, and packed in Flat No. 2 cans. Seasoning juice of "shoyu" is added to each can. The packed and sealed cans are processed as usual. The processing is held at 237°F (114°C, 9 lb-pressure) for 60 minutes.

3. "Teriyaki" of yellow-tail (a kind of canned seasoned fish)

The cut meat of moderate size prepared as for canned seasoned yellowtail, is broiled on skewers over a charcoal fire. After broiling, the meat is soaked in a seasoning juice made from "shoyu", removed from the juice, and is broiled again on a wire-net. The broiled meat is packed in cans (Flat No. 1 can), and processing is held at 110 C (6 lb-pressure) for 60 minutes.

4. Smoked yellow-tail in oil

The meat cut lengthwise is soaked in a brine of Bé 12° for 2 days and the salted meat is desalted in fresh water, drained for a day and smoked at 70~85°F in a smoke-house for 8~11 days. The smoked fish is cut into moderate size pieces and packed with vegetable oil. As in the case of canned smoked salmon, heat sterilization is not required.

II. Canning of Sea-Bream

Sea-bream meat is white and its flavor is bland. It is only processed as canned seasoned fish meat after the dressed fish is broiled over a charcoal fire to harden the meat. The fish is then packed in cans, to which the seasoning juice is added. Sea-bream is primarily canned as fish paste ("tai-miso"). "Tai-miso" is prepared from crushed meat mixed with soy bean paste ("miso"), and seasoned with sugar followed by heating. The production of canned "tai-miso" is relatively large. Both canned seasoned sea-bream and "tai-miso" are consumed by the domestic market.

III. Canning of Cod and Alaska pollack

Cod is plain in taste. A small amount of canned cod and canned Alaska pollack (boiled or seasoned) are produced. The processing is not special.

The known reactivities in Maillard reactions of several sugars and sugar phosphates and their concentrations in cod muscle after different periods of chill-storage can account for many of the variations in browning potential that muscle shows.(78) In addition, the importance of free sugars in the reactions that lead to browning in the muscle of white fish under canning conditions has long been recognised.(79) Motohiro et al.(80) have investestigated the extent of browning discolorations of canned cod using raw material which being vary periods of chill storage in ice. According to their results, the best correlations were obtained between ribose concentration and extent of discoloration in the separated liquor of canned cod.

CRAB-CANNING INDUSTRY

I. Importance

The crab canning industry in Japan was started in the vicinity of Otaru, Hokkaido, around 1892, and in the following year the product was forwarded to the Fishery Exhibition held at Cornwell, England. This was the first shipment of Japanese canned crab meat ever exported to a foreign country. The industry remained undeveloped for some time thereafter. With the favorable market conditions that prevailed in 1908, however, a number of interests commenced to operate crab canneries in Hokkaido and South Sakhalin, and a continuous increase was registered in production. The growth of the industry was specially striking in the year after the great earthquake of 1923. It is a fact, however, that the production of canned crab reached a level of 400 to 500 thousand cases per year only after the development of the crab canning industry in Kamchatka and the remarkable rise of the floating canneries. The floating canneries, which were an entirely new undertaking created by the Japanese and which have been playing an outstanding part in the crab canning industry in this country, were originally started in 1916 on an experimental basis. The result of the experiment proved promising, and in 1920, a set of canning machinery was installed on a sailing ship of about 150 tons, aboard which a small quantity of crab was packed. Since then the industry has developed. The number of floating canneries increased year by year, until in 1923 there were 15, of which 8 were sailing ships and the remaining 7 steamers. The total tonnage of these craft was 9,000 tons. Further gains continued to be made. In 1930, the number of steamers equipped with crab canning facilities was 19, while their total tonnage reached as high as 64,000 tons. By this time, vessels of considerably large sizes had come to be placed in operation, some of them were over 7,800 tons. The tonnage of such floating factories averaged in the same year around 34,000 tons. Along with the steady progress attained each year in production facilities, a phenomenal improvement was also being made in the organization of the enterprises, until finally all the floating canneries were consolidated in 1932, under a new organization known as "the Nippon Godo Kosen Kaisha" (The "Nippon Floating Canneries Company, Ltd.). The company had 5-8 floating canneries from 1933 to the beginning of World War II. From 1942 to 1951 there were no floating canneries in operation.

After the war, in 1956 one floating cannery has sailed to Bristol Bay according to the Peace Treaty and since this year four floating canneries have sailed every year to the Okhotsk Sea. The size of these ships averaged about 6,000 tons. On the other hand, after the war crab fishing in the seas along Hokkaido resumed slowly and the production reached 139,367 cases for canned king crab and 65,515 cases for other kinds of canned crabs (mainly horse-hair crab) in 1951. The total production including all kinds of canned crabs increased to 1,091,105 cases in 1968. The total production of canned king crab in the Okhotsk Sea is restricted by the Russo-Japanese Fishery Conference which is held every year; e.g. it was 260 thousand cases in 1960. The difference between the total production of all kinds of canned crab and that processed on the floating canneries is accounted for by the production of the land based canneries in Hokkaido.

II. Varieties of Crab

There are a number of varieties of crab among the crustacea, but those which are used for canning in Japan are limited to Alaska king crab ("taraba-gani", *Paralithodes camtschatica*), "abura-gani" (*P. platypus*), "hanasaki-gani" (*P. brevipes*), horse hair crab ("ke-gani", *Erimacrus isenbeckii*) and "zuai-gani" (*Chionoecetes opilio*).

Alaska king crab is the largest among crabs, averaging about 12 pounds (5.5kg) in weight and measuring from 3 1/2 to 4 feet from tip to tip of the legs. The carapace is small in comparison to the legs, measuring between 7 and 9 inches across, and is covered with spines, the number of which is employed as a means of species identification.

"Hanasaki-gani" and "abura-gani" which are not found in Alaskan waters are in the Bering Sea. These crabs are comparatively less abudant, so they are of minor importance. "Zuai-gani" is found on the Japan Sea coasts of Honshu in Japan and Korea. It is good in flavor, but not very abundant. The canning of "zuai-gani" is also a minor industry.

Horse-hair crab ("Ke-gani") canning next to importance to the canning of the king crab in Japan. Horse-hair crab are found along the western coast of Sakhalin and in waters to certain extent.

III. Fishing Grounds and Fishing Seasons

Alaska king crab ("taraba-gani") abounds in the cold and pure deep sea water off the coaste of Sakhalin, Hokkaido and along the Okhotsk Sea, while small amounts are caught off the coast of Korea. These northern sea coasts are washed by clean and cold currents; the temperature of this sea water is approximately 3°C.

Japanese floating canneries are now operated along the western coasts

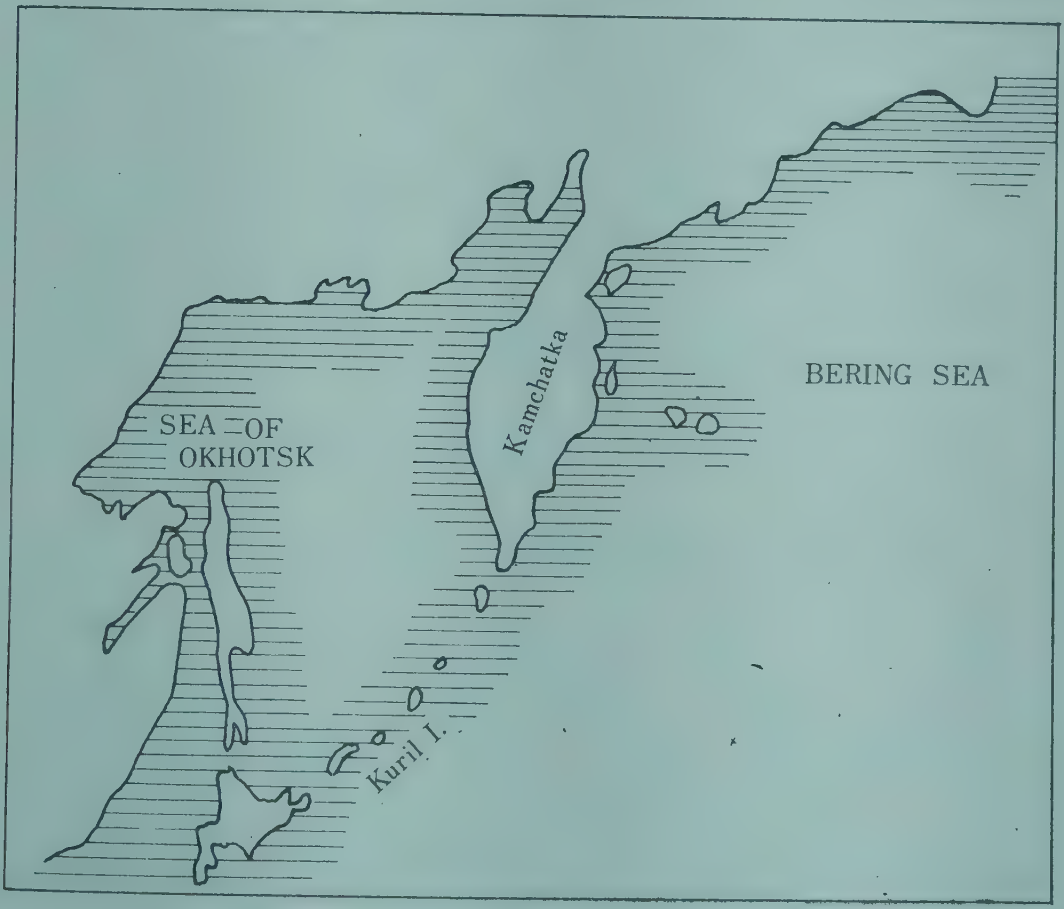

Fig. 4-9. Principal crab fishing grounds of Okhotsk and Bering Sea waters

of Kamchatka and in Bristol Bay. The fishing grounds are 3 to 50 knots off the coast, where the water is 40 to 60 fathoms in depth. The crab fishing season varies according to the species and the territory.

In Hokkaido the fishing season of king crab usually starts commonly in early March and ends the latter part of August. The fishing season of "Hanasaki-gani" starts in northern Hokkaido in June and ends in October. The peak of the season is from July to October. The fishing season of "ke-gani" starts in the Kitami District in Hokkaido in February and ends in June. "Zuai-gani" is fished in Fukui, Kyoto and Shimane Prefectures from January to March.

The operation season for floating canneries extends from the early part of April to the beginning of September ; May and June are regarded as the best part of the season.

IV. Fishing Methods

The catch "taraba-gani", a motor boat of Japanese type known as "Kawasaki-sen" is used, from which a crab net of the fixed gill net type is set in the fishing ground, in a fence-like fashion extending to the sea bottom. The net consists of 60 to 200 lengths ("tan"). Each length is 10 feet deep and 7 fathoms (42～43m) long. This means that a vast net is stretched along the bottom of the sea to an extent of from 10,000 to 30,000 feet in length. Immediately after the fixed gill net is set in the water, a marker buoy is fixed on the spot, and the boat returns to its base or to the floating cannery (mother ship). After a few days to a week, the motor boat returns to the spot to haul up the net, togather with crabs which have become entangled therein, and returns to its base or the floating cannery.

"Ke-gani" is captured in traps called pots, of which the shape and dimensions differ by districts, but which operate on the same principle. In general, they are conical cages made from circular bamboo frame work and cotton wire net, in which bait is placed. These pots have an iron wire funnel shaped opening, usually inclined obliquely downward, through which the crabs pass in their search for food. Once inside the trap, the crabs can not escape. The pot commonly used in Hokkaido has a circular bamboo frame as its bottom, of which the diameter is 80~100 cm, and its height is about 50 cm. The diameter of the opening about 30 cm and the length of the funnel attached to the opening is about 15 cm. Almost any kind of fresh, salted, or stale fish or squid are used as crab bait. The pots are either set on single or on trawls having from 3 to 20 traps attached.

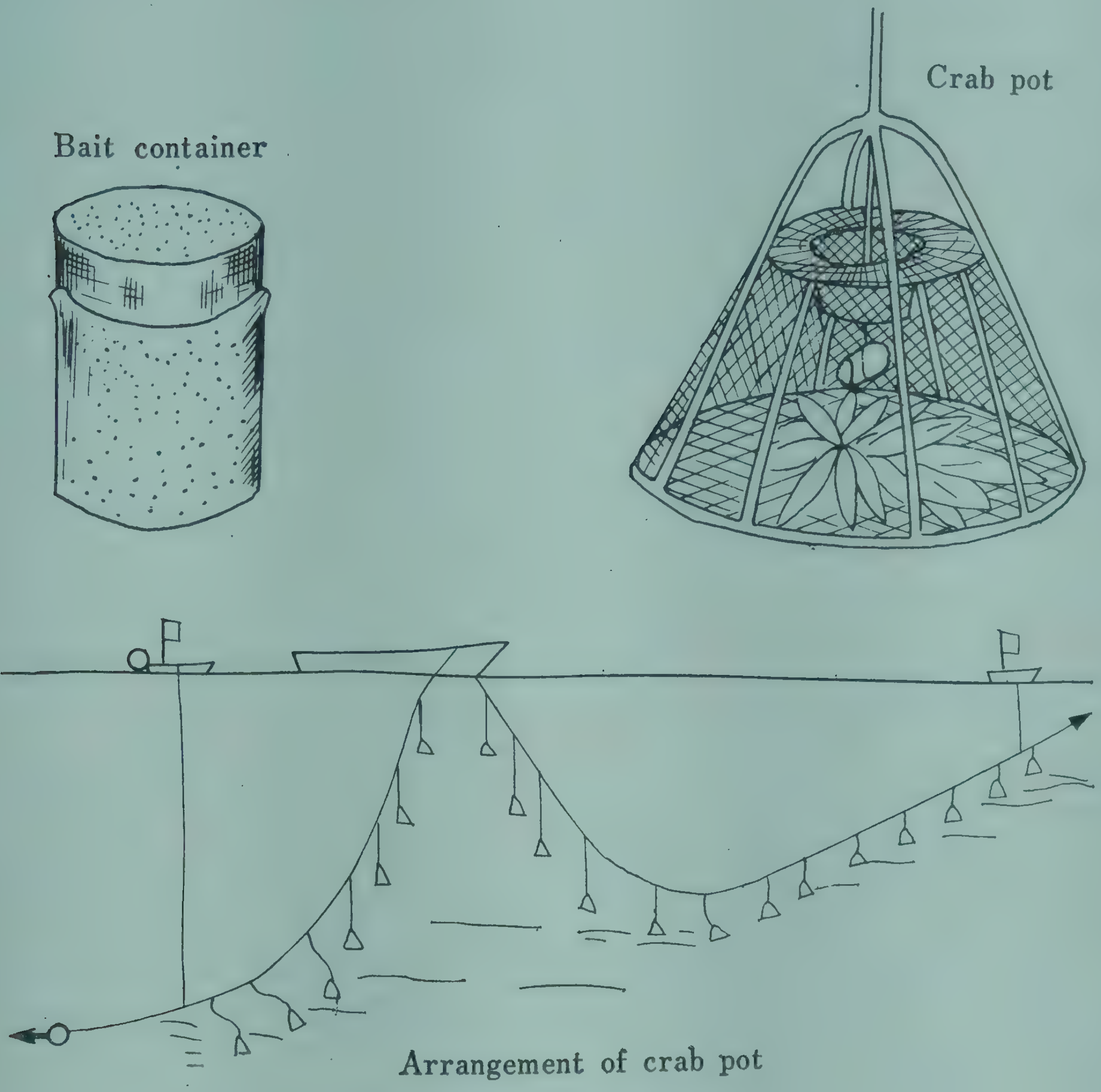

Fig. 4-10 A crab pot

V. Production of Canned Crab

Economically the crab canning industry is one of the most important enterprises in Japan; Here we will look in retrospect on the production in the past. It is noted that the annual production of canned crab had always been below 200,000 cases prior to the year 1920, while the fishing grounds were limited to small areas off the coast of Hokkaido and the Kuril Islands. It is also apparent that processing facilities were not yet fully developed. Yet the future of industry was then viewed with gloomy forebodings in spite of an appreciable improvement in the demand from abroad. It seemed that the crab family of crustaceans was nearing exhaustion due to overfishing. In 1920, however, floating canneries were started as above mentioned. Simultaneously, crab canning facilities were established in Kamchatka. The situation was altered completely by these developments and an increase was registered in the production each year, until the amount of the pack reached 580,000 cases in 1930. Factors contributing to this remarkable development were numerous, but they may be summarized as follows: (a) Improvement in canning processes which brought about a better quality of product thereby stimulating demand both at home and abroad ; (b) Improvement and enlargement of fishing facilities, keeping pace with the growth of demand ; (c) Japanese extension to new fishery areas in Kamchatka and the Maritime Province of Eastern Siberia where "taraba-gani" abounds ; (d) Systematic regulation of catching and packing ; (e) Consolidation of hitherto competing canning companies ; and, (f) Finally the development of floating canneries. Due to the severity of the protracted World-wide economic depression, however, canners had to control their production since 1931, and the annual output was limite dto appoximately 300,000 cases in these last years until 1941 (World War II). During the war the production ceased. After the blank in production during the war, the crab canning industry reopened in 1956 in Bristol Bay, and in the Okhotsk Sea in 1957. However, production is restricted by the Fishery Treaties.

In 1932, the packers united in establishing a joint sales cooperative, "Nippon Kani Kanzume Kyodo Hanbai Kaisha" (the Japanese Canned Crab Cooperative Sales Company, Ltd.), through which all canned crab is sold both within the country and abroad. In several years, the annual production reached about 700,000 cases. The annual production of canned crab packed by Japanese interests is shown in Table 4-38. Crab meat is packed principally in crab No. 2 flat can (a half pound) or crab No. 3 flat can (a quarter pound).

Table 4-38. Production of canned crab in 1968

Kinds	Real no. of cases	Converted no. of cases
King crab	689,975	222,238
Horse-hair crab	23,504	8,544
Hanasaki-crab	24,148	8,215
Zuai-crab	351,188	123,002
Others	2,290	445
Total	1,091,105	362,444

VI. Exports of Canned Crab

Almost all the production of canned crab is exported to foreign countries. The amounts exported and destination are shown in Table 4-39.

Table 4-39. Export of canned crab in 1969

Kinds	Real no. of cases	converted no. of cases	Destinations
King crab	158,300	66,677	U.S.A., U.K., France, Canada, Hawaii, Belgium, Australia
Horse-hair crab	1,289	53	U.S.A., Sweden, Belgium, France, Australia
Hanasaki-crab	10,494	4,317	U.K., Sweden, Belgium, France
Zuai-crab	157,524	64,768	U.K., Sweden, France, Australia
Others	657	149	U.S.A.
Total	328,267	136,443	

VII. Procedure for Canning King Crab

King crab is packed either on the floating canneries or on land. The procedures in both cases are almost the same.

1. **Removal of the carapace**

The crabs which are captured by tangle nets (bottom gill nets) and hauled on the deck have the carapace removed from the bodies while the fishing boats are returning to the floating cannery. This is done by hooking the shell over the sharp edge of a removing tool. Thus the legs are separated from the carapace. If the carapace is not removed, the enzymatic action of the liver contained therein will break down the crab shoulder meat (the base of the legs), and the percentage of the meat obtained after the cooking is decreased.

2. Cooking

The carcasses from which the carapace has been removed are put into net bags with about 1.5 inch mesh made of Manila twine. They are then heated in boiling sea water. The boiling time is calculated from the time the sea water resumes boiling after the addition of the crabs. The boiling time is about 18～20 minutes for big crab (hard crab) when 200 carcasses are put in at one time, and about 17～18 minutes for small carcasses which can be put in at a rate of over 300 carcasses at one time. The carcasses of which the freshness has declined must be boiled 2～3 minutes longer than the above times. The boiling vats are made of iron and are square (5.0×5.0×5.5ft.). These tanks are heated by steam which is passed into the water through perforated pipes in the bottom of the vats.

3. Cooling

After the cooked carcasses are removed from the cooking vat, they are cooled in cold sea water for about 10 minutes before further handling. By cooking, the meat becomes easy to separate from the shell, because of its increased firmness.

4. Separation of meat from the shell

The separation of meat from the shell is done by knife or scissors. The percentage of the meat obtained by knife is less than that by scissors by 10～20%. The meat separated from the shell is divided into body meat (shoulder meat), first leg meat, joint meat, second leg meat and claw meat, and put into separate pans. Those classes of meat are kept separate until packed in the cans.

5. Washing

After the separation of meat from the shell, it is transferred into the the washing cages which are made from bamboo and washed in a tank of sea water.

6. Selection of meat

After the washing, most of the body meat (shoulder meat) holds its shape. Miss-shapen body meat and leg meat are down grade to "Flake meat". The first leg meat is cut into segments the height of the can. The joint meat and the second leg meat hold their shape and are used for the decorative meat of the "Third grade style" canned crab. The meat is graded into "Fancy"-, "Fair"-, "Third" (Passed A, B)-styles.

7. Packing

The prepared crab meat is usually packed in parchment paper lined C-enameled 1/2-pound flat can, of which the net weight is about 230 g. Occasionally a packer will use 1/4 or 1-pound flat cans for special markets.

The grades of canned crab are "Fancy", "Fair", "Third grade"("Passed A and B"). In the preparation of the "Fancy" style cans, 2～4 large pieces of the first leg meat are placed in the top and bottom layers in order to present a good appearance and the shaped shoulder meat, joint meat, and claw meat are placed at the sides. "Flake meat" is placed in the center. According to the Japanese Inspection Regulation, the weight of the meat in 1/2-pound flat can of "Fancy" class style must be above 185 g, of which the first leg meat (2～4 pieces) must amount to 53 g, and "Flake meat" must be less than 55 g. The rest is shoulder meat, joint meat and claw meat. The "Fair" grade consists of cans which were packed as "Fancy". style, but in which the quality of the contents was not graded as "Fancy". The "Third"-style are the cans in which more than 185 g of the meats have been packed and the second or third leg meats of the broken meat (not flake meat) are placed in the top and bottom layers of the content.

8. Addition of salt

In floating canneries, as the sea water is used for washing and boiling, the further addition of salt is not needed. But when fresh water is used in land canneries, salt must be added at the rate of about 2 g per 1/2-pound can.

9. Sealing

After the cans are packed, the tops are clinched and then are vacuum-sealed.

10. Processing

The sealed cans are placed in a retort and processed for 80 minutes at a temperature of 227°F (108°C)~228.5°F (109°C) (5~5.5 pounds pressure). The time required for the temperature of the retort to reach to the processing temperature must be at least 10 minutes.

11. Cooling

After the processing and as soon as they are removed from the retort, the cans must be cooled quickly in a spray of cold water or in a cold water cooking tank.

12. Sounding inspection

After the cans are examined by striking them with a small metal rod, to check for vacuum, they are packed into wooden of fibre board cases, holding 96 or 48 half-pound flats.

VIII. Procedure for Canning Horse-hair Crab ("Ke-gani") employed by Land Based Packers

Horse hair crab ("ke-gani") are canned at land based canneries. The carapace is removed from the crab body by the method used for king crab.

1. Cooking

The carcasses from which the carapace has been removed are cooked in boiling water, fresh water to which salt is added, or sea water for 15~18 minutes after the water resumes boiling. After cooking the carcasses are quickly cooled.

2. Separating meat from the shell

The shell of each leg is cut at 3 pieces with a large knife. One side of the shell of the first leg is chipped by the knife and the meat is removed from the shell by the pressing with a beer bottle as with a roller press. This meat easily breaks and becomes "Red flake meat". Damaged shoulder meat becomes "White flake meat".

3. Washing

Horse hair crab meat must be more carefully washed than king crab meat in order to prevent the appearance of blue meat.

4. Selection of meat

The muscular fibre of the horse hair crab is thinner than that of king crab and more likely to crumble. After removing the meat from the shell, the undamaged meat and broken meat must be separated, and extraneous matter attached to the meat must be removed. The broken meat becomes white or red "Flake meat".

5. Packing

Horse hair crab meat is generally packed in parchment paper lined C-enameled, 1/2 pound flat tin cans, or 1/4-pound flat tin cans. The net weight of the meat is about 250g in the 1/2-pound flat tin cans. From 4 to 6 pieces of the first leg meat are placed in the top and bottom layers. Between the top and bottom layers, white "Flake meat" is placed outside and red "Flake meat" is placed on the inside. The ratio of white and red "Flake meat" should be 6 : 4. When use is made of fresh water for washing and cooking, salt must be added when the meat is filled. The grades of canned horse hair crab ("ke-gani") are divided into "Fancy" and "Choice" classes.

6. Processing

The cans are vacuum sealed and processed for 90 minutes at a pressure of 227°～228.5°F (108°～109°C, 5～5.5 pound pressure). The time required for the retort to reach processing temperature must be at least 10 minutes.

IX. Inspection of Canned Crab Meat

In Japan, canned crab for export must be inspected according to the regulations of the Japanese Canned Foods Inspection Association. When the contents of the canned crab are inspected, the appearance of the contents after the opening, the shape, packing condition, and color of flesh are scored.

The grades of A and B in canned king crab are "Fancy" and "Fair", and in canned flake meat of the same "Passed A" and "Passed B". The grades of canned horse hair crab ("ke-gani"), "hanasaki-gani" and "zuai-gani" are A ("Choice") and B ("Standard"). The criteria of inspection of the "Fancy style" canned king crab have been set by the Japanese Government.

X. Scientific and Technical Problems

1. **Blackening in canned crab**

In the early day of crab canning, losses were suffered from the blackening of the canned crab meat. This blackening was caused by the combination of hydrogen sulfide which generates from the meat during the boiling and processing with ferrous ion dissolved from imperfection in the tin plate with the resulting formation of ferrous sulfide (a black substance). This reaction occurs readily at alkaline reaction of the crab meat in which the freshness has declined. This blackening can be prevented by the addition of acid, e.g. tartaric acid or citric acid, in the can, or the use of a parchment paper lining and with C-enamel cans.(Fellers and Parks(81) 1926; Legendre(82) 1928; Oshima(83) 1927). The former method aims at retarding the generation of hydrogen sulfide from the crab meat by adding organic acids while the latter method prevents the formation of ferrous sulfied by isolating the hydrogen sulfide and ferrous ion and rendering the combination difficult.

2. **Blue discoloration**

The problem of the blue discoloration in canned crab meat has caused trouble until recent times. The blue meat often appears not only on the surface of crab meat in the cans, but also, though rarely, on crab meat several hours after boiling and cooling of the carcasses. The blue meat appears more often on the surface of joint of shoulder meat, claw meat and other leg joints. It appears in canned horsehair crab meat ("kegani") more often than in king crab. The appearance of the blue meat is undoubtedly due to the copper contained in haemocyanin which is a component of the blood of mollusca or artheopoda.(84)

Recently, Inoue and Motohiro (85) have investigated on a cause and mechanism of blue discoloration. Copper contents in blue and normal meats of king crabs were 2.80mg% and 0.49mg% (wet weight) in average, respectively. Higher copper contents were found in the shoulder meat, surface of first leg, and meats nearer a joint and claw meat than those in other parts. The limit of copper above which blueing occurs appears to be about 2mg%. The haemocyanin contained in crab haemolymph can react with hydrogen sulfide to produce a blue colored pigment by heating(100°C, 15 minutes). Heat coagulated haemocyanin may also react with hydrogen sulfide to give a blue color by heating. Reflectance spectrum of haemocyanin-sulfide complex closely resembles that of the blue meat. The chemical composition of a blue substance that the blue meat of canned crab was digested by protease was in accord with that of king crab haemocyanin-sulfide complex, apart from the sulfide content. And they concluded that the causative substance of the blue discoloration of canned crab meat is haemocyanin-sulfide complex.

Osakabe (86) has succeeded in preventing the appearance of the blue meat of the canned crab by "Low-temperature and fractional heating" of the carcasses from which carapace had been removed. According to his experiments, the coagulating temperature of blood protein of crabs is from 69°C to 70°C, and that of meat protein of crabs is from 59°C to 60°C. Thus, if the carcasses are heated at 59°C~60°C the meat coagulates, but the uncoagulated blood will run out. After removing the meat from the carapace in a half-heated condition, the blood will run out leaving the meat alone. When the meat from which the blood has been removed is boiled for a few minutes and packed in can as the usual manner, the blue meat will not appear in the finished product. In addition, when the "low-temperature and fractional heating" method is used, canned tendonless (boneless) crab meat may be prepared. In Japan the introduction of Osakabe's method made an epoch in the procedure of canning crab meat.

3. Abnormal odor of canned crab

The odor of canned crab meat which has decomposed can be classified into two kinds. One is an odor which resembles the combined smell of burned rice and of cooked soured rice. The other is an ammonia-like odor containing sweet and bitter tones. The cause of the former may be the packing of the raw material of which the freshness has declined and its glycogen fermented. The cause of the latter odor is thought to be bacterial decomposition. Most of the canned crab which have the latter odor will undergo swelling when the cans are incubated. In order to prevent those off-odor in canned crab, the raw material must be handled rapidly in order to maintain its freshness and contamination in the cannery and its equipment must be kept at a minimum. Observance of good plant sanitation procedures and cleanliness is essential.

4. Flat sour in canned crab

In early times, the cause of the flat sour of canned crab was said to be thermophiles. However, Tanikawa and Motohiro have made it clear that the cause of the flat sour is the accumulation of organic acids (formic and butyric) which were generated from the decomposition of crab meat before the processing. The bacteria in the crab meat are sterilized by the processing, so that the cans do not swell. However, the meat becomes sour.

5. Swelled canned crab

In Japan, in order to preserve the good flavor of crab meat even after the processing, the processing temperature is low such as 227°F (108°C) ~228.5°F (109°C) (5~5.5 lb-pressure). Such canned crab has rarely swelled.

Tanikawa et al. (88) (89) have isolated some thermal tolerant bacteria, *B. subtilis var.* (*B. mesentericus*), and *B. megatherium* from swelled canned crab. When the meat is fresh, even if such bacteria are present, their numbers are few and do not increase. Thus the cans and contents are rendered sterile by the usual processing method. In order to avoid the swelling of the canned crab, the cannery and canning machines and tools must be thoroughly disinfected and cleaned at frequent intervals.

6. Browning of canned crab meat

The color of normal commercial canned crab meat is generally white, but, in the canned crab prepared by the usual processing ("high temperature boiling method") in shore canneries in Hoakaido, and in that prepared by "low temperature boiling method" on floating canneries, it is occasionally observed that the white meat has turned partly to brown in color. When this "browning" phenomenon occurs, the market value of canned crab concerned is seriously reduced. This phenomenon has raised a serious question in the canned crab industry. Nagasawa (90) has studied this "browning" phenomenon and come to the following conclusions: (1) Canned crab meat did not become brown when fresh raw crabs had been used and subjected to the usual boiling method ("high temperature boiling method"): (2) Canned crab meat always developed a brownish color when stale raw material had been used and was subjected to the "high temperature boiling method"; (3) When the "low temperature boiling method" was employed, the canned products became brown regardless of the degree of freshness of the raw material; (4) "Browning" was considered to be caused by the combination of amino acids and reducing sugars in crab meat during the processing (Maillard reaction) based on the following experimental results: a) If either one of both amino acid and reducing sugar was removed from the raw crab meat as result with acetylation or fermentation, the meat of the finished product did not turn to brown. b) N-glycosides formed in the initial stages of the Maillard reaction were isolated from both boiled crab meat and browned crab meat. c) Fluorescent substance and hydroxymethylfurfural which are intermediate products of the Millard reaction were separated from both boiled crab meat and browned canned crab meat; d) Melanoidins which are the end products of the Maillard reaction were separated from browned canned crab meat and their absorption peak appeared at 280～284-mμ. Other properties were also compared with those of melanoidins obtained from a model system, and the properties of both groups were almost identical. He proposed three methods to prevent "browning", (1) Improving the preservation methods of the crabs so as to keep them in a fresh state until they are landed and processed; (2) Improvement in the boiling methods; and (3) Picking out and discarding the boiled meat containing a fluorescent substance (a precursor of the brown pigment).

SHRIMP-CANNING INDUSTRY

I. Importance

In Japan "Hokkai-ebi" (*Pandalus kessleri*) is packed as canned shrimp. This shrimp lives in cold sea waters along northern Hokkaido and the Kurile Islands. The length of the body is about 15 cm. This shrimp is fished by gill net or purse seine and is caught in the summer and autumn. The annual production of this species is about 100 tons in Hokkaido. The production of canned shrimp in 1968 is shown in Table 4-40.

Table 4-40. Production of the canned shrimp in 1968

Kinds	Real no. of cases	Converted no. of cases
Boiled shrimp	295, 153	47, 720
Smoked shrimp in oil	3, 007	365
Total	298, 160	48, 085

The amounts of canned shrimp exported and the destinations are shown in Table 4-41. Canned shrimp is exported mainly in the form of canned

Table 4-41. Export of canned shrimp in 1969

Kinds	Real no. of cases	Converted no. of cases	Destinations
Boiled shrimp	52, 465	12, 417	U.S.A., Canada, U.K., France, Australia, Okinawa

boiled shrimp.

II. Procedures for Canning Shrimp

1. Boiled Shrimp

The shrimp are "picked" or "peeled" entirely by hand. First shrimp head is removed. In removing the head, the yellow substance attached to the cut end of the head must be completely removed. The carcasses are then washed. The washed carcasses are placed in a baskets, which are lowered into a tank of boiling of 6° to 9° Bé brine for 2 to 3 minutes. After boiling and cooling the meat is removed from the shell. The black streak attached to the upper part of the meat must be removed. The meat is then soaked in an acid solution (one pound of tartaric acid dissolved in 10 gallons of water) for about 15 minutes. After soaking, the meat is washed, drained and placed in a basket and steamed for about 15 to 30 minutes. Upon steaming the meat becomes red and curved into a comma-shaped. The meat is cooled and dried in the shade. If the drying is done directly in the sun the meat developes an off or sun burnt odor. The degree of drying grade is very important in maintaining the shape. When the water content of the meat is large, the shrimp will link together. After the drying the meats are graded by size, and filled into parchment lined C-enameled cans. In the case of "Dry pack", the net weight of the meat in 1-pound flat can is 245 g, and that in 1/2-pound flat can is 118 g. The filled cans are vacuum sealed without heat exhaust. "Dry pack" shrimp in 1-pound flat cans are processed 90 minutes at 227°F (108.4°C, 5-pound pressure). Half-pound flat cans are processed for 80 minutes at 227°F.

In the case of "Wet pack", a small quantity of brine of 6° Bé (24° salinometer) is added to each can. "Wet pack" shrimp in 1-pound flat cans are processed 20 minutes at 227°F. Half-pound flat cans are processed 18 minutes at the same temperature. After processing, the canned shrimp should be rapidly cooled in a tank.

2. Smoked shrimp in oil

The peeling and the removing of the head and the shell are done in the same way as in the preparation of canned boiled shrimp. The meat obtained is smoked on a wire basket in a smoke house. The smoked shrimp meat is packed in square cans with vegetable oil. The cans are processed at 200°F (93°C) for 30～45 minutes.

III. Scientific and Technical Problems

In the preparation of canned shrimp, blackening, softening and discoloration may cause trouble.

1. Blackening

The cause and the method of prevention in the blackening of the canned shrimp are the same as for canned crab.

2. Softening

The cause of softening of canned shrimp is the decomposition of the protein to soluble non-protein substances. This decomposition takes place in the raw material when freshness declines. In order to prevent this condition, strictly fresh raw material should be employed and the sanitary conditions of the cannery must be carefully mainained at a high level.

3. Loss of color

The original red color of canned shrimp declines during long storage periods. In order to prevent such loss of color, the raw shrimp should be dipped in an acid solution after the shell is removed.

OYSTER-CANNING INDUSTRY

I. Importance

In Japan, "ma-gaki" (*Ostrea laperousei*) and "suminoe-gaki" (*Ostrea rivularis*) are used for the canning of boiled oysters. The latter is the most fit for this purpose, but the catch is not very large. The former occupies the next place in quality, and the catch is abundant.

The production of raw oyster without shell was 38,037 tons in 1967. The main places of production are Miyagi (3,727 tons), Iwate (1,141 tons), Okayama (1,095 tons) and Hiroshima (28, 438 tons) Prefectures. The amount produced in Japan is next to that in the United States (about 89, 000 tons).

The oyster is prepared as canned boiled oyster, smoked oyster and seasoned oyster or roasted oyster on skewers.

The production of canned oyster according to type is shown in Table 4-42.

The amounts of canned oysters exported are shown in Table 4-43.

Table 4-42. Production of canned oyster in 1968

Kind	Real no. of cases	Converted no. of cases
Boiled oyster	787, 429	196, 887
Smoked oyster	728, 937	92, 414
Seasoned oyster	6, 159	2, 761
Other oyster	2, 954	1, 069
Total	1, 525, 476	293, 131

Table 4-43. Export of canned oyster in 1969

Kinds	Real no. of cases	Converted no. of cases	Destinations
Smoked oyster in oil	327, 692	90, 566	U.S.A., Canada, West Africa, Holland, West Germany, Australia, U.K.
Boiled oyster	328, 565	164, 289	U.S.A., Canada, Australia, New Zealand, West India, Belgium, West Africa.
Others	4, 119	2, 422	
Total	705, 376	257, 277	

II. Canned Boiled Oysters

Only large fat and good shaped oysters should be used for this product. Generally oysters which were shucked in the raw condition are used. However, in large-scale production the shells are shucked after steaming.

Oyster which are shucked in the raw condition are washed with 2 to 3 per cent salt solution, and drained. The washed meats are steamed from 10 to 15 minutes at 212°F (100°C). The oysters with the shell are steamed in a retort from 10 to 15 minutes at 245°F (118.3°C) (12-pound pressure). During steaming the shells of the oysters open and lose a great portion of their juice. The meat is removed from the shell while hot and is then carefully washed, and drained. After inspection and grading, the prepared meats are packed into cans. The filled cans are conveyed to the sealing machine where from 1 to 2 per cent brine is added and the cans are sealed. Time of processing depends on the size of the can. Half-pound flat cans are usually processed for 40 minutes at 230°F (110°C)(6-pound pressure). After the processing, the cans are rapidly cooled.

III. Canned Smoked Oyster in Oil

1. Raw material

The raw oysters are landed on the sea shore where they are shucked by hand. The shucked oysters are taken to the cannery in barreles. They are then mixed with 3 to 6 per cent salt in order to remove the mucous substance on the surface of the body. They are held in contact with the salt for 1 or 2 hours.

2. Washing

After treatment with salt the oysters are washed carefully in fresh water. In washing, the fresh water is agitated with compressed air.

3. Boiling

The washed oysters are heated in boiling water for 3 minutes to make the meat firm. After the boiling, the meat is cooled in a water tank.

4. Inspection and grading of meat

The boiled oyster are placed on metal trays and workmen scan them and remove the broken pieces or portions otherwise unfit for canning. They are graded by the size as “Large”, “Medium”, “Small” and “Thin”.

5. Steaming

The oyster meats are placed on trays in single layers and placed in a steam cooker. Different canners use different steaming times, for example, one steams the meat for 20 minutes at 212°F (100°C), another from 10 to 20 minutes at 215°F (101.8°C). Care must be taken not to steam the oysters too rapidly, otherwise meat may split.

6. Smoking

After cooling, the steamed oysters are placed in a smoking room and smoked for 20 to 40 minutes at temperatures of from 122°F to 176°F (from 50°C to 80°C).

7. Packing

If the smoked oysters are to be packed as "Large", the count in a No. 3-B square can should be from 10 to 20 pieces. "Medium" may run from 21 to 30, "Small" from 31 to 40, and "Thin" from 41 to 55. The weight of the smoked oyster must be about or over 85 g and the added oil (cotton-seed or olive) over 15 g for this size container. The total net weight must be over 105 g.

8. Processing

The filled cans are vacuum sealed and processed for 60 minutes at 229.8°F (109.9°C) (6-pound pressure) and then water-cooled.

IV. Canned Seasoned Oysters

Shucked and washed oysters are boiled in water for 3 minutes (to make the meat firm) and cooled in cold water. After the cooling, they are boiled in a seasoning juice made from "shoyu" and sugar. Then seasoned oysters are then packed in cans, to which a small quantity of the same seasoning juice is added. The cans are sealed and then are processed at 230°F (110°C) for 60 minutes and cooled.

V. Care in Canning Oysters

In the canned oysters, the shape of the individual oysters must not be broken. After they are steamed they must be handled very carefully.

CANNED ABALONE

The abalone ("awabi"), also called "sea ear" or "ear shell" belongs to a family of marine snails which includes 8 species. In Japan there are four species: "awabi" (*Haliotis gigantea*) "megai" (*Haliotis sieboldi*) "kuro-awabi" (*H. discus-discus*) and "ezo-awabi" (*H. discus hannai*). Besides "awabi", Japanese abalone ("tokobushi", or "nagareko", *Haliotis japonicus*) inhabits in the sea of Hokkaido. The main places of production are Hokkaido, Iwate, Chiba and Nagasaki Prefectures. The amount of the production of raw abalone without shell in Japan was 5, 958 tons in 1967. Abalone is used for drying and canning. But it is relished for eating raw or after having been boiled. *Haliotis japonicus* ("tokobushi" or "nagareko") is also prepared for the same purpose, but is known as canned "nagareko".

The kinds of canned abalone are boiled, smoked in oil, seasoned, and roasted on skewer. Canned abalone is produced in Iwate, Miyagi and Mie Prefectures. The production of canned abalone is shown in Table 4-44. The amounts of the canned abalone exported are shown in Table 4-45.

Table 4-44. Production of canned abalone in 1968

Kinds	Real no. of cases	Converted no. of cases
Boiled abalone	9, 941	4, 697
Seasoned abalone	274	73
Others	248	31
Total	10, 463	4, 801

Table 4-45 Exports of canned abalone in 1969

Kind	Real no. of cases	Converted no. of cases	Destinations
Boiled abalone	518	321	Hawaii, U.S.A., Singapore

The procedure for preparing boiled abalone is as follows: The meat is shucked leaving mantle and viscera in the shell by a special tool. The shucked meat is then dry-salted (10 % salt) for from one to two nights.

The material is mixed from time to time in order to ensure uniform salting. After the salting, the meat is rubbed to remove mucous and other substances, and then washed thoroughly. After washing, the meat is held in fresh water for 1-2 hours to freshen, and is then drained. The drained meat is packed in cans. The fill-in weight is 300 g for No. 4 cans (tall 1 1b). Fresh water is added to complete the fill and the cans are vacuum sealed. The canned abalone is processed at 235°F (113°C, 8-pound pressure) for 60～90 minutes.

Smoked abalone is prepared by smoking the salted and freshed abalone, the smoked meat is packed with vegetable oil.

Seasoned abalone is prepared by adding seasoning juice ("shoyu" and sugar) to the abalone.

Roasted abalone is prepared by placing small cubed pieces of the freshed raw material on skewers followed by roasting over a charcoal fire. Seasoning juice is added to the roasted abalone.

Smoked abalone and roasted abalone are packed in mainly square cans. Seasoned abalone is packed in No. 4 can (tall 1 1b) as is boiled abalone. The processing temperatures of these cans are almost the same for boiled abalone, but the times are somewhat shorter.

Precautions for canned boiled abalone: The products should be moderate firmness. For good quality the meat should be of amber color, and the individual pieces should be of uniformly large size. The juice must be transparent. If the washing in the preparation is insufficient, the juice becomes turbid.

CANNED TOP-SHELL MEAT

Top-shell ("sazae", *Turbo cornutus*) is not produced very abundantly. The annual production was 7, 192 tons without shell in 1967. In Japan this sea food is preferably eaten after roasting in its own shell. This shell-fish lives in warm sea waters, but the main places of production are Chiba, Niigata, Fukui, Shimane, Yamaguchi, Fukuoka and Nagasaki Prefectures. This shellfish meat is seasoned and canned in the usual manner. Only a small amount of canned smoked top-shell meat in oil is produced. The production of canned top-shell meat in 1968 was

24, 709 cases (real no. of cases). The amount of canned seasoned top-shell meat exported was 2, 195 cases in 1969, and the destinations were the U.S.A., Pacific Ocean islands and Okinawa.

The procedure for preparing canned boiled top-shell meat is as follows: The raw shellfish are boiled for 7～13 minutes in order to remove the meat with viscera from the shell. After removal, the viscera and mantle are cut off from the meat. The meat is washed with fresh water and boiled in seasoning juice made from "shoyu" and sugar. The seasoned meat is packed in cans (flat No. 2 can) and processed at 232°F (111°C, 7-pound pressure) for 60 minutes.

CLAMS-CANNING INDUSTRY

I. Importance

Clams are also one of the most popular and important shellfish in Japan. Clams are classified scientifically into many families and genera. In Japan, there are found many species of clams which are economically important. For example, there are: fresh water clams ("shijimi", *Corbicula leana*), hard clams ("Hamaguri", *Meretrix mertrix lusoria*), short-necked clams (baby clams, "asari", *Venerupis philippinarum*), hen clams ("Hokki-gai", *Mactra sachalinensis*), and "aka-gai" (*Anadara inflata*). The catch of baby clams was 121, 618 tons in 1967. The main places of production of hard clams are Ibaragi, Chiba, Mie and Kumamoto Prefectures, and those of short-necked clams are Chiba, Tokyo, Kanagawa, Aichi, Fukuoka, Kumamoto, Hyogo, Okayama, Hiroshima and Yamaguchi Prefectures. In Japan, clams are mainly served raw, though some are also canned boiled, or seasoned in whole meat style. The general procedure, excepting the removal of the siphons, is similar for all species. In some species this part is included with the whole meat as it increases the yield to a considerable extent.

Production of canned hard clams was 33, 418 cases in 1968 (real no. of cases). The production of canned short-necked clams in 1968 is shown in Table 4-46. The export of short-necked clams in 1969 was 310, 889 cases, and principal destinations exported was U.S.A., Canada, Italy, Australia and other Europian countries. The export of hard clams is small.

Table 4-46. Production of short-necked clams (baby clams) in 1968

Kinds	Real no. of cases	Converted no. of cases
Boiled baby clams	255, 088	90, 497
Smoked baby clams in oil	126, 137	15, 315
Seasoned baby clams	151, 427	59, 053
Total	532, 652	164, 865

II. Preparation of Canned Hard Clams and Short-Necked Clams (Baby Clams)

1. **Canned boiled whole clams**

a. Raw material

Hard clams and short-necked clams for canning should be fresh and even grained.

b. Boiling

The clams are placed in a basket, and washed with fresh water. After washing, the basket of clams is heated in boiling water about 4~5 minutes. The clams meat is then removed from the shells by hand.

c. Packing

The boiled clams are spread in thin layer on the filling table to cool and to permit removal of the broken pieces and parts otherwise unfit for canning. The respective net weights of clams are packed into cans of various sizes, for example, for the No. 4 can (tall 1 1b-content) the net weight is above 227 g. Salt (5.6 g) to which tartaric acid has been added in the proportion of 1/1, 000 is added to 1-pound tall cans.

d. Processing

Hot water is added to the packed cans, and they are exhausted and sealed. The 1-pound tall cans are processed for 70 minutes at 240°F (116°C, 10-pound pressure). Recently the swelling of the canned short-necked clams owing to the presence of thermotolerant bacteria has been observed and the processing is often done at 249°F (120°C, 15~16-pound pressure) for 90 minutes to prevent this type of spoilage.

2. **Seasoned clams**

Hard clams and short-necked clams are seasoned as "Tsukuda-ni" or "shigure-ni" with "shoyu" and sugar. The hard clam or short-necked clam meat removed from the shell is seasoned by boiling first in a dilute seasoning juice made from "shoyu" and sugar ("shoyu" 2 liter, sugar 58~640 g) for 50~60 minutes, followed by boiling for 30 minutes in a rather concentrated seasoning juice and finally by boiling again with a still more concentrated juice. The firmness of "tsukuda-ni" meat is due to the fact that is boiled more times than is "shigure-ni". In practice "tsukuda-ni" is boiled 4 to 5 times as compared with 3 times for "shigure-ni".

The boiled clam meat is packed in cans sealed, and processed at 224°F (107°C, 4-pound pressure) for 60~70 minutes.

The big clams removed from the shell are placed on skewers and roasted over a charcoal fire. The roasted clams are packed with the skewers in cans.

3. **Smoked short-necked clams in oil**

Short-necked clams removed from the shell are smoked on a wire tray in a smoke-house. The smoked clams are packed in cans with vegetable oil and are processed at 230°F (110°C, 6-pound pressure) for 60 minutes.

CANNED HEN CLAMS

I. Importance

Hen clams ("hokki-gai", *Mactra sachalinensis*) is called "uba-gai" in Japan. The shell is about 9.5 cm in length, 7.5 cm in height, and 5.3 cm in width. This shell fish inhabits cold sea waters. The size of the meat as removed from the shell is rather large. The places of production are Sakhalin, Hokkaido and Tohoku districts. The amount produced (without shell) in 1967 was 4,947 tons. Most of these hen clams were caught in Hokkaido (4,763 tons). This shell fish meat is served at the table after boiling or drying. A great portion of the catch is packed. The production in 1968 was 2, 590 cases.

The two kinds of the canned hen clam are; (1) boiled and (2) seasoned. There are two methods in the preparation of the canned boiled product: (1) raw and (2) boiled packing.

II. Boiled Hen Clams

1. Raw packing

Shucked hen clams are washed and the siphon cut to remove the sand. The visceral matter is squeezed out by fingers. The base of the black mantle is removed and washed with dilute brine, and drained. The drained raw material is packed in 1-pound flat cans to weight of 250 g, 3.5 g salt is added. The cans are exhausted and sealed or vacuum sealed. The 1-pound flat cans are processed for 90 minutes at 106°C (3.5 pound pressure). Half-pound flat cans are processed for 70 minutes at the same temperature.

2. Boiled packing

Shucked hen clams which have been washed and subjected to removal of the mantle are heated in boiling water. The boiled liquor is filtered through cotton cloth and cooled. The boiled meat is packed in 1-pound flat cans to which the filtered clear liquor is added. The weight of the boiled meat is 300 g in 1-pound flat cans. The process is the same as in case of the raw-packing.

III. Seasoned Hen Clams

Hen clams are sometimes seasoned with seasoning juice made from "shoyu" and sugar the same as in the case of canned seasoned oysters.

IV. Precautions in Canned Hen Clams

Sand may be present in the juice of the canned clams. Therefore the clams must be induced to expel the sand in the digestive organ while they are alive in sea water or in dilute brine solution, in which the pH value is adjusted to about 4.8. (91) Blackening of the canned clams often may occur. Tanikawa et al. (92) have studied the cause of can swelling and blackening of canned baby clams. The blackening is caused by the formation of copper sulfide and iron sulfide. Iron transferred to the intestine from the mud where the clams live, is involved in blackening. Also implicated copper free from copper protein in baby clam by boiling. The amounts of hydrogen sulfide are usually below 50 mg%, which may be the minimum amount necessary to cause blackening. When hydrogen sulfide is produced in amounts more than 50 mg%, blackening may be accelerated, or the canned baby clams may decompose and hydrogen sulfide concentration increase slightly during storage. They also investigated on the bacterial action involved in can swelling and blackening of baby clams. (93) Six strains of bacteria (three involved in blackening, two in swelling, and one in both blackening and swelling) were isolated from blackened meat of baby clams in swelled cans. Of these bacteria, certain species which may be related to the blackening may decompose copper protein to liberate copper. The bacteria involved in blackening form hydrogen sulfide by decomposing sulfur-containing amino acids such as cysteine. The hydrogen sulfide produced reacts with copper and iron to make sulfides, and blackening occurs. Spoiled clams seldom contained only one species of causative bacteria. Both meat blackening and can swelling may possibly occur in the same pack of canned baby clams.

Tanikawa et al. (94) have proposed a method which is based on removal of bacteria from the digestive tract by means of electrophoresis for the prevention of the blackening spoilage of canned baby clams. Removal of SG-2 bacteria from the intestine of baby clam could be accomplished by electrophoresis. SG-2 bacteria are responsible for the blackening and swelling of canned baby clams. Appling 15 volts for 30 minutes made baby clams of low bacterial contamination bacteria free, and decreased high bacterial contamination from 10^5 to 10^3. Complete removal of bacteria from highly contaminated baby clams required that the medium (water) in the electrophoretic instrument be changed 2～3 times during electrophoresis. Addition of 10 ppm of an anionic surface-active agent (sodium tetradecyl sulfate) increased the rate of removal of bacteria from highly contaminated baby clams.

Some phosphate compounds (0.2 %)and C-enamel lined cans are effective in decreasing the blackening.

CANNED "AKA-GAI"

The raw meat of "Aka-Gai" (*Anadara* (*Scapharca*) *inflata*) is violet red in color. Because of red color of the raw meat, it is called "aka-gai" (red shell-fish meat). The red color of the raw meat is said to be due to the presence of haemoglobin in the blood. This shell is almost quadrilateral in shape being about 11.5 cm in length, 9.5 cm in height and 7 cm in width. The shell-fish is produced widely in bays in Hokkaido (Hakodate), Honshu (from Aomori to Yamaguchi"), and in Kyushu. The annual production is about 6 thousand tons. The raw meat is soft and delicious and is served at the table as "sushi", or seasoned with "shoyu" and sugar, or with added vinegar. Some quantity of the catch is used for canning as a seasoned product. The production of the canned seasoned "aka-gai" in 1968 was 886, 152 cases. Only small amount of canned "aka-gai" is exported. The procedure for making canned seasoned "aka-gai" is almost the same as that for canned seasoned oysters. "Aka-gai" is sometimes roasted on skewers, and packed in cans.

SCALLOP-CANNING INDUSTRY

I. Importance

The ligament of the scallop is very delicious and is frozen or canned as well as being manufactured for dried goods.

The scallop belongs to the *Pectenidae,* of which two species are commercially important in Japan : Scallop ("hotate-kai", *Pecten yessoensis*) and "itaya-kai" (*P. laqueatus*). Besides the *Pecten,* the ligament of "tairagi" (*Pinna Pectinata japonica*) resembles that of "hotate-kai". The canned ligament of "tairagi" is called canned "hira-gai" (flat shellfish). There is one species in Japan, which resembles *Pecten yessoensis*, "akazara-kai" (*Chlamy farreri akazara*), and from which a big ligament is obtained.

Scallops are found in the cold sea of Hokkaido and Mutsu Bay in Aomori Prefecture, and are caught by beam trawl fishing. The catch was 6, 819 tons in 1967. The catch of the other species is rather small. The main places of production are only in Hokkaido (5, 095 tons) and Aomori (1, 719 tons) Prefectures.

The kinds of canned scallop are boiled and seasoned. A small amount of canned smoked scallop is also processed. The production of canned scallop in 1968 was 38, 860 cases, and that of "hira-kai" was 138, 371 cases.

Export of canned boiled scallops in 1969 was 230 cases.

II. Boiled Scallop

When raw scallops are unloaded at the cannery, each 10 shells are put into a basket which is heated for 3 minutes in boiling water. Upon heating the shells of the scallops are opened. The body is then removed from the shell. The ligament (adductor muscle, "eye") is separated out, because it is the only part of the scallop which is valuable as food ; this is the part which is packed in cans. The remainder (mantle and visceral sack) is utilized in other ways. The thin membrane which surrounds the ligament must not be removed in washing, because if it is removed, the muscle fibre of the ligament will break up. After washing, the ligament is boiled in dilute salt solution for 15 minutes. After the boiling, it is cooled. The cooled ligament is packed in 1-pound flat cans or half-pound flat cans, and 2 percent salt solution is added. One-pound flat cans are required to have a net drained weight of above 260 g. For half-pound flat cans, the net drained weight is above 130 g of the ligament meat. After packing, the cans are vacuum sealed and processed for 70 minutes at 230°F (110°C, 6-pound pressure) for 1-pound flat cans, and 60 minutes at the same temperature for 1/2 1b flat cans. The ligaments of the other species which resemble the scallop are processed in the same way as is canned scallop.

III. Smoked or Seasoned Scallop

The ligaments of the scallop are sometimes smoked and packed in cans with vegetable oil, or they are seasoned with seasoning juice made from "shoyu" and sugar.

IV. Precautions in Canning Scallops

In the canned scallop, loss of shape and browning of the meat are causes of trouble.

1. **Loss of shape of the ligament (adductor meat)**

Loss of shape of the ligament meat occurs when the thin membrane which surrounds it is removed in washing. Therefore care must be taken not to remove this thin membrane from the ligament meat as noted above.

2. **Browning of canned scallop**

The browning of canned scallop may be caused by heating in a dry pack product and by using unfresh raw material. Therefore excess heating must be avoided and fresh material must be employed.

CANNING OF OTHER SHELLFISH

There are certain other shellfish which are processed for canning but the total production is small. Fox example, "bai" (*Babylonia japonicus*) or "mate-gai" (*Solen gouldis*) are canned as a seasoned products. The former is a kind of coil shell, and the latter is a long cylindrical shell, also called a razor shell. They are widely distributed in Japan. However, the production of these shellfish is rather small and they are not economically important.

CANNED SQUID

I. Importance

There are many species of squid or cuttle-fish, among which common squid ("surume-ika", *Ommastrephes sloani pacificus* = *Todarodes pacificus*) is caught abundantly in Japan; it is used for drying, smoking and canning. The production of common squid was 773 thousand tons in 1968. The main places of production are Hokkaido, Aomori, Iwate, Niigata, and Nagasaki Prefectures. In Japan, the common squid is canned both as the boiled and the seasoned products. The production of canned boiled squid in 1968 was 35,501 cases, and that of seasoned squid was 680,526 cases. The amount of canned squid exported in 1969 was 146,287 cases and its principal destinations were Singapore, Malaya, Phillippine, Europe and Okinawa.

II. Boiled Squid

1. Whole boiled squid

The cephalopoditic part of the squid to which the viscaral mass is attached is removed from the mantle cavity. The visceral mass is cut off from the cephalopoditic part and the latter separately washed. After the washing, they are heated at about 45°C in salt water (Bé 10°) (40° salinometer) for 15 minutes, after which the skin may be readily removed. The peeled meats are heated in boiling salt solution (Bé 3°) (12° salinometer) for 10 minutes. After boiling, the eyes are removed from the caphalo part. The meats are carefully washed, and packed. Three hundred g of the meat of the mantle cavity in which the cephalopoditic part is located are packed in C-enamel lined 1-pound tall cans and 40g of brine (Bé 4°) (16° salinometer) and 13g of the following mixed solution are added. The mixed solution is prepared by mixing 8 g of sodium glutamate and 2 g of citric acid per liter of water. The packed cans are exhausted, and sealed, and processed at 229.8°F (109.9°C, 6-pound pressure) for 85 minutes. After the processing, the cans are rapidly cooled.

2. Minced boiled squid

The preparation meat from the mantle cavity and cephalopoditic parts is the same as in the preparation of whole style squid. The peeled meats of the mantle cavity and the cephalopoditic part are ground in a chopper (1/2 to 1/3 inch mesh). The minced meat is packed into 3-pound tall cans and hot brine (Bé 2°～3°) (8°～12° salinometer) which contains a small amount of butter or lard is added. The cans are processed at 232.4°F (111.3°C) (7-pound pressure) for 110 minutes.

III. Seasoned Squid

Seasoned squid meat is eaten in Japan and Korea. The method of preparing the meats of mantle cavity and cephalopoditic parts is the same as in the whole style method. The meat is seasoned with a seasoning solution. After having been seasoned, the cephalopoditic part is put into the mantle cavity, and 300g are packed into a 1-pound tall can and 30g of the seasoning solution is added. The seasoning solution is prepared mixing 2kg of "miso" (soy paste), 2.5kg of sugar, 1kg of salt, 25 liters of "shoyu" (soy bean sauce) and 10 liters of water. The cans are vacuum sealed and processed for 60 minutes at 224.4°F (106.9°C, 4-pound pressure).

IV. Precautions in Canning Squid

Peeling of the surface skin (epidermis) of the squid without prior boiling (denaturation of the meat protein) is difficult. Autodigestive skinning at a temperature of 45°C is satisfactory. However, for the canned squid, the meat must be boiled thoroughly, hence the skinning of the squid is done after it is boiled.

CANNED OCTOPUS (DEVIL FISH)

I. Importance

There are three species of octopus found in Japan; "madako" (*Octopus vulgaris*), "mizu-dako" (*Octopus dofleini*) and "ii-dako" (*Octopus ochellatus*).

"Ma-dako" is about 60cm in length; it lives mainly in Honshu and southward. This species is consumed as raw fish. "Mizu-dako" inhibits the cold water zone, and is caught from the Tohoku district northwards. This species is large in size (some have a spread of about 3 meters). Its flavor is inferior to that of "ma-dako", but it is economically important because the large quantity of edible meat obtained.

"Ii-dako" is small (about 24cm). It inhabits the warm water zone like "ma-dako". The roe of this species resembles rice grains in shape ("ii" means rice). The flavor and taste of this meat and of the roe is delicous.

"Mizu-dako", "ii-dako" are canned mainly as seasoned food ("yamato-ni", "teri-yaki", roasted on skewers with added vinegar, smoked, etc.). The total catch of octopus including all three species was 98,130 tons in 1967. The main places of production are Hokkaido, Aomori, Miyagi, Fukushima, Aichi, Hyogo, Hiroshima, Yamaguchi, Kagawa and Ehime Prefectures.

The production of canned octopus, which is largely consumed by the domestic market was 9,900 cases in 1968.

II. Boiled Octopus

The whole body of the fresh octopus is rubbed with salt and washed in order to remove the mucous substance on the surface of the body. The eyes and jaw are removed by means of a knife. The body is put into a boiling dilute salt solution (Bé 3°) and cooked for 10～12 minutes. After cooling, the body is sliced into small pieces. A definite quantity of the small pieces is packed in cans (No. 2 flat can, 1/2 1b-content), to which about 4g of salt is added. The packed cans are processed as usual. The processing schedule is 235°F (113°C, 8-pound pressure) for 60 minutes.

III. Seasoned Octopus

The pieces of octopus meat which were prepared as for the canned boiled product, are seasoned with seasoning juice made from "shoyu" and sugar. The seasoned meat is packed and processed. The processing is carried on under the same conditions as for canned boiled octopus.

IV. "Teri-yaki" Octopus

The sliced meat of boiled octopus is grilled over a charcoal fire after soaking in the same seasoning juice as mentioned above. The roasting and the soaking are repeated two or three times. The roasted sliced octopus meat is packed and roasted. This is called "kushi-yaki" (roasted meat on skewers).

V. Smoked Octopus

The boiled whole body is smoked hanging in a smoke-house. The smoked body is cut in slices which are packed in cans with vegetable oil, and processed.

VI. Pickled Octopus

The sliced meat is soaked in a vinegar solution (vinegar, salt, sugar, sodium glutamate, pH 3.6) over night. The next day, vinegared meat is packed in cans (No.3 can) with a small amount of added vinegar and processed at 218°F (106°C, 2-pound pressure) for 30 minutes.

VII. Canning of "Ii-dako"

"Ii-dako" is canned as boiled or seasoned. The bodies of "Ii-dako" are boiled in a dilute salt solution. When canned boiled "ii-dako" is prepared, the boiled bodies are packed in cans with a small quantity of salt.

When canned seasoned "ii-dako" is prepared, the bodies are first seasoned with the seasoning juice made from "shoyu" and sugar. They are packed whole style in cans and processed.

WHALE MEAT CANNING INDUSTRY

I. Importance

The whaling industry in Japan began about 1600 in the form of hunting with harpoons. Netting was adopted in 1670. The Norwegian whaling technique (harpoon gun hunting) has been employed by the Japanese since 1899. Whales killed by harpoon guns are towed to the shore stations, where the carcass is processed. Shore stations have been situated in Hokkaido, Iwate, Miyagi, Wakayama, and Yamaguchi prefectures.

Whaling with a factory ship by the Japanese was started in 1934. Since World War II seven factory ships have been operating in the Antarctic Ocean. On the other hand, two factory ships have again operated in the northern Pacific Ocean from May to August every year since 1952, and an average of about 2,000 whales per years are taken. In addition five whaling companies have operated smaller whaling boats near the Japanese Islands since 1945. The total number of whales caught amounted 21.586 in 1967～1968.

In Japan, the fresh meat of some cetaceans has been used for human consumption from earliest times, especially tail meat and blubber of musticeti such as the common finback or sei whale. During and after World War II, not only the red flesh of these whales, but also that of sperm and bottlenose whales were used. Formerly, the flesh of sperm or bottlenose whales was not eaten on account of its purgative action and peculiar odor. The name given to whale meat varies depending upon the section of the body from which it is obtained. Red meat ("aka-niku") is the back meat, which is consumed as daily food. It is frozen or salted before being brought to the domestic market. The tail meat ("ono-mi") is red meat with connective tissue from the anus to the tail fin; it is the most palatable and is eaten as raw meat ("sashimi") in the same manner as tuna fish meat in Japan. The ventral meat ("sunoko") is the connective tissue located inside of the ventral blubber. This meat has recently been used very largely for canning. The chest meat

Table 4-47. Production of canned whale meat in 1968

Kinds	Real no. of cases	Converted no. of cases
Boiled whale meat	4,104	2,986
Seasoned whale meat	554,673	232,384
Seasoned whale flake meat	144,287	69,026
Roasted whale meat	788,613	378,442
Roasted whale flake meat	102,118	64,031
Others	9,274	4,383
Total	1,614,271	760,551

(“munaita”) is red meat. The above meats are used for food, while other muscle meat are used for extracting oil or for fertilizer. Among these meats, red meat (“aka-niku”) and ventral meat (“sunoko”) of mysticeti are processed as canned seasoned meat. The red meat of sperm whale also has come to be used for canning.

The production of canned whale meat which is consumed by the domestic market is shown in Table 4-47.

II. Procedures for the Canning of Whale Meat

Some whale meat (connective tissue) is prepared as canned boiled meat, but the greater part is packed as canned seasoned meat.

1. Seasoned whale meat from “sunoko”

Blocks of 15～20 kg of frozen connective tissue (“sunoko”) are thawed in water tank. The thawed meat is cut to rectangular blocks 30×5 cm, which are boiled in water for one hour and cooked. The cooled blocks are then sliced with a mechanical slicer. The sliced pieces of meat are seasoned by boiling in a seasoning juice made from “shoyu” and sugar. The seasoned meat is packed with added seasoning juice and two or three pieces of ginger. The ginger serves to mask the peculiar odor of whale meat.

2. Seasoned whale red meat

The back red flesh is soaked in running water in a tank, to which blocks of ice are added in order to remove the blood and thus reduce its peculiar and characteristic odor. The other procedures are the same as in preparing “seasoned-sunoko”. No.4 tall cans are processed at 232.4°F (110.6°C, 7-pound pressure) for 60～90 minutes.

3. Roasted whale meat

Blocks of whale meat cut to 5 cm^3 in size are boiled in the seasoning juice made from “shoyu” and sugar with some piece of ginger for about ten hours. The seasoned blocks are roasted in an oven, and then sliced. The sliced meat is packed with added seasoning juice in small flat of square cans. The cans are then vacuum sealed and processed.

4. Seasoned whale meat with vegetables

Sometimes the seasoned meat is packed with seasoned vegetables.

CANNED SEAWEEDS

In Japan, dried "nori" (or laver) is used for canning after having been seasoned with "shoyu" and sugar. (This products are called "tsukuda-ni"). Dried laminaria in small pieces is also used for canning after seasoning with "shoyu" only; (this is called "shio-konbu"). "Shio-konbu" is a very salty food. The production of canned "nori-tsukuda-ni" was about 50,000 cases in 1959. And the production became 105,433 cases in 1962. The production of canned "shio-konbu" is small.

The procedure for preparation of canned "nori-tsukuda-ni" is as follows. Generally dried "nori" is used as the raw material. It is crushed and soaked in the seasoning juice made from "shoyu" and sugar over night. The next day the "nori" is boiled with the same seasoning juice for two hours. Sweet "sake" and sodium glutamate are added to the seasoning juice. The seasoned "nori" ("tsukuda-ni") is packed in cans and processed.

OTHER CANNED MARINE FOODS

Fish balls, fish sausage or Japanese "kamaboko" or "chikuwa" which are kinds of fish paste are packed in cans for sending abroad where Japanese who are living abroad. The production of such canned foods amounted to about 113,795 cases in 1968.

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DRIED MARINE PRODUCTS

The preparation of dried marine products is one of the most important fishery industries in Japan. Propery speaking, the dried products are prepared for the purpose of preservation, but more recently they are being employed as a raw material for seasoned foods.

I. Kinds of the Dried Marine Products

Dried marine roducts may be classified as follows :

1. Plain dried products : Fish or algae are dried in the sun or in a drier after being carefully washed. These products include squid ("surume"), octopus ("hoshi-dako"), shark fin ("fuka-bire"), air-bladder ("gyoto"), cod ("botara"), herring ("migaki-nishin"), pressed sardine ("tatami-iwashi"), tetoradon-fish (globe-fish)("hoshi-fugu"), herring roe ("kazunoko"), laminaria ("konbu"), laver ("hoshi-nori"), undaria ("wakame") and "funori".
2. Boiled and dried products : Fish are dried after being boiled. These products include abalone (amber or dark grey color)("kai-ho"), sea cucumber (with or without papillae) ("iriko"), sardine ("niboshi-iwashi"), shark cartilage ("meikotsu"), shrimp ("hoshi-ebi"), shark fin ("taishi"), addubtor (ligament) of shellfish ("hoshi-kaibashira"), sand lance ("niboshi-ikanago"), and shellfish meat ("niboshi-kai").
3. Broiled and dried fish : Fish that are dried after being broiled, include sea-bream ("hamayaki-dai"), "ayu" ("yakiboshi-ayu"), sardine ("yakiboshi-iwashi").
4. Salt-dried fish : Fish is salted slightly and dried under the sun or in a drier. Such products include sardine ("shio-boshi-iwashi"), cod ("shioboshi-tara"), yellowtails ("waramaki-buri"), pompanos (jack mackerel) ("enkan-aji"), mullet-roe ("karasumi").

5. Frozen and dried products: Fish or the gelatinous extract of algae are frozen and thawed and dried several times. Such products are cod or Alaska pollack ("mintai") and agar-agar ("kanten").
6. Boiled, roasted and dried fish ("fushi"): Fish are boiled after beheading and eviscerating, and are then roasted in an oven and dried. Bonito (*Katsuwonus pelamis*), tuna (*Thynnus sibi*) and mackerel are processed in this manner.
7. Seasoned and dried products: Fish fillet or sliced meat or mollusca are seasoned with the seasoning juice (soy bean sauce ("shoyu") and sugar, sweet "sake", etc.), and then dried by smoking or in a drier. Such products are relatively new, e.g. smoked squid meat or filleted Alaska pollack meat.
8. Smoked fish: Fish as it is, or dressed fish are smoked in a smoke house. These products include smoked herring, salmon, mackerel, saury, cod and other fish.

II. Production of Dried Marine Products

The production of various dried marine products for food use are shown in Table 5-1.

Dried marine products are mainly produced in Hokkaido, Aomori, Iwate, Miyagi, Fukushima, Ibaragi, Chiba, Tokyo, Kanagawa, Niigata, Toyama, Ishikawa, Shizuoka, Aichi, Mie, Kyoto, Osaka, Hyogo, Wakayama, Tottori, Shimane, Okayama, Hiroshima, Yamaguchi, Tokushima, Kagawa, Ehime, Kochi, Fukuoka, Saga, Nagasaki, Kumamoto and Kagoshima Prefectures.

Over 10 thousand tons per year are produced in each of these prefectures. Products of the amounts of various kinds of dried products to the total amounts of raw material caught are shown in Table 5-2.

As seen in Table 5-2, the production of plain dried products did not increase from 1966 to 1968, but in comparison with the production in 1965, the production has actually decreased somewhat. The reason for the decrease is the change of Japanese food habits.

The production of boiled-dried products has also decrease gradually from the year 1965. The reason is also the decreaseing of the catch of

Table 5-1. Production of various kinds of dried products (for food use) (tons)(1966～1968)

Kinds	1966	1967	1968
Plain dried fish			
Squid	21,327	25,114	27,041
Herring	5,279	9,555	10,760
Sardine	1,023	1,260	1,233
Cod and Alaska pollack	4,478	3,643	4,283
Others	5,032	4,200	1,456
Total	38,505	45,184	48,578
Salt-dried fish			
Sardine	29,573	27,813	27,808
"Aji"	28,994	34,880	37,499
Saury	15,907	13,819	10,071
Mackerel	9,247	8,790	9,986
Atka mackerel	9,247	8,790	9,986
Others	21,602	26,184	27,621
Total	121,079	125,208	134,845
Boiled and dried fish			
Sardine	56,265	58,831	52,371
Sand lance	4,544	6,339	8,345
Shrimp	3,312	4,340	3,748
Others	18,180	18,839	12,053
Total	82,731	88,855	101,628
Smoked fish			
Salmon	504	309	351
Squid	1,271	2,517	2,866
Others	2,552	5,981	1,905
Total	6,422	8,962	12,255
"Fushi" (dried fish stick)			
Bonito	12,591	11,026	11,531
Bonito (half-dried)	9,683	8,999	8,942
Mackerel	11,044	9,493	13,935
Others (include sliced "Fushi")	49,544	51,988	54,458
Total	83,435	81,653	89,183
Dried seaweeds	62,087	76,094	67,559
Grand total	499,455	507,050	570,497

Table 5-2. Proportion of the amounts of various kinds of dried products to the total catch of raw material (1965～1968) (1,000 tons)

Item		1965	1966	1967	1968
Total amount of the catch		6,907	7,102	7,850	8,670
		(100)	(100)	(100)	(100)
Amount of raw material as fresh fish		2,440	2,352	2,522	2,672
		(35)	(30)	(32)	(30)
Total amount or raw material as dried foods		1,039	954	997	1,079
		(14.9)	(13.4)	(12.7)	(12.7)
As	Plain dried products	183.7	166.4	189.5	202.2
		(2.6)	(2.3)	(2.4)	(2.3)
	Salt-dried products	208.7	213.1	216.6	236.6
		(3.0)	(3.0)	(2.7)	(2.7)
	Boiled-dried products	442.4	366.9	394.9	417.7
		(6.3)	(5.1)	(5.0)	(4.8)
	Smoked products	24.0	18.1	25.4	26.4
		(0.3)	(0.2)	(0.3)	(0.3)
	"Fushi" (Dried fish stick)	190.3	190.3	170.9	195.6
		(2.6)	(207)	(2.1)	(2.3)

sardine. There are demands that production of some products increased such as dried shellfish ligament, sea cucumber, abalone, shrimp which are demanded for trade with China. The production of salt-dried products has also decreased year by year because of a decrease in the catch of raw material and changing food habits.

The production of smoked fish has increased recently because of its use as a delicacy for eating with "sake" or beer. The seasoned-dried (smoked) fish are put in the category of the smoked fish. For example, the production of seasoned smoked squid and octopus meat increased remarkably. These meats are customarily marketed in sanitary polyethylene film bags.

The production of "fushi" has been stationary for several years. "Fushi" has been used for seasoning from ancient times in Japan. With the advent of chemical seasoning material, e.g. sodium glutamate, ribonucleotids, it was thought that the demand for "fushi" would decrease, but instead these two natural and chemical types of seasoning have continued to coexists. "Fushi" is being used in combination with sodium glutamate and ribonucleotids. The bonito-"fushi" will increase further, if the supply of bonito as a raw material is abundant.

The total production of dried seaweeds has decreased, due mainly to the decrease of the laminaria. However, the production of "Kuro-nori" (dried laver) increased owing to an increase of production areas.

Simple processed products like dried marine foods are manufactured primarily small scale private concerns whose total number comes to about 80,000. They are engaged in both fishing and processing. The number of those small type operations accounts for about 94 % of the total number of manufactures. The large concerns which are incorporated in companies, and of which the number comparises about 4 % of the total, are engaged in processing more elaborate products such as canned foods or fish sausage. The export or dried marine products was valued at 8~9 million dollars in 1968. Among these products, dried ligament, abalone, and squid are of greater importance.

PLAIN DRIED PRODUCTS (AIR-DRYING)

Here, the processing of plaine dried products will be discussed in order of the amount of production.

I. Dried Squid

The dried squid ("surume") has been one of the most important exports for China from ancient times. Large quantities of squid or cuttle fish are dried annually as "surume". There are many important species caught in Japan.

1. Species

The important species of squid caught in Japan are as follows: *Ommastrephes sloani pacificus* (*Todarodes Pacificus*) ("surume-ika"), *Symplectoteuthis ovalaniensis* ("tobi-ika"), *Watasenis scintillans* ("hotaru-ika"), *Sepiella maindroni* ("ma-ika"), *Sepia subaculeata* ("kaminari-ika"),

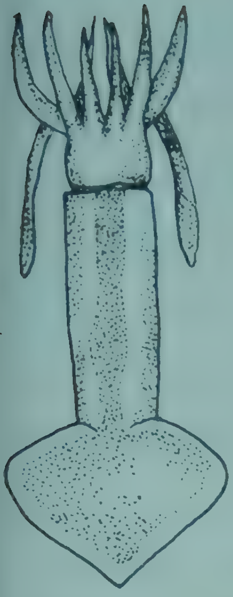

Fig. 5-1 *Ommastrephes sloani pacificus* ("surume-ika")

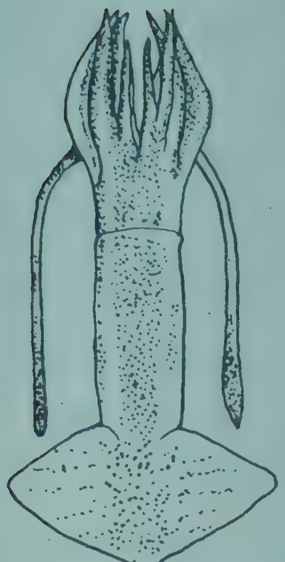

Fig. 5-2 *Symplectoteuthis ovalaniencis* ("tobi-ika")

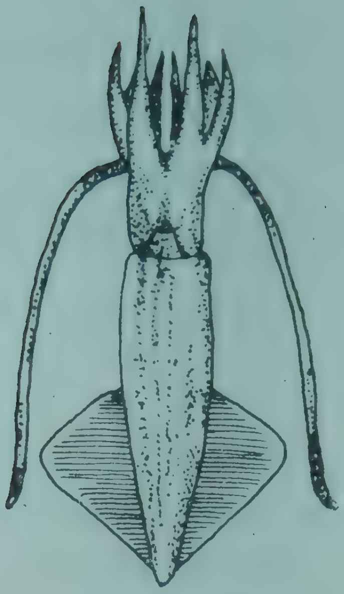

Fig. 5-3 *Watacenia scintillans* ("hotaru-ika")

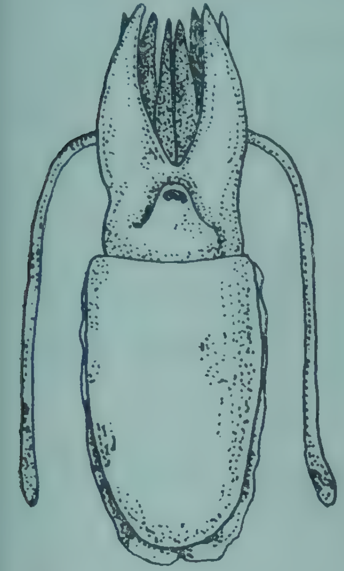

Fig. 5-4 *Sepiella maindroni* ("ma-ika")

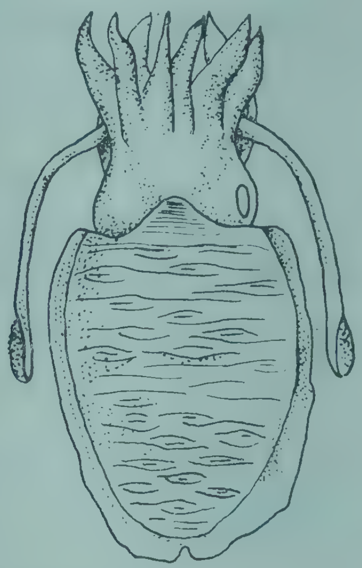

Fig. 5-5 *Sepia subaculeata* ("kaminari-ika")

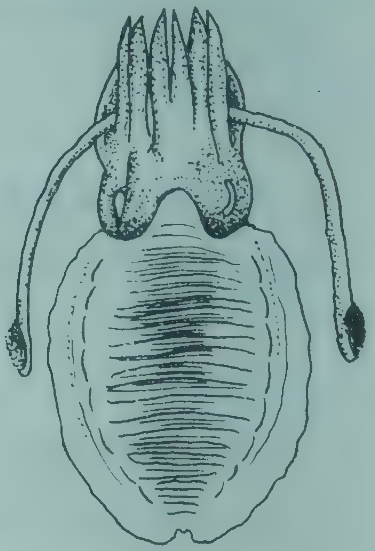

Fig. 5-6 *Sapia esculenta* ("ko-ika")

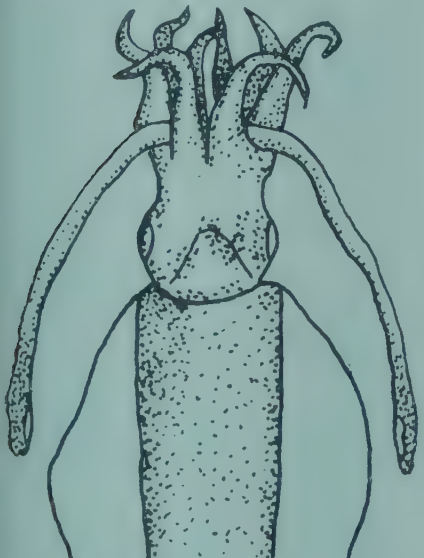

Fig. 5-7 *Sepioteuthis lessoniana* ("afuri-ika")

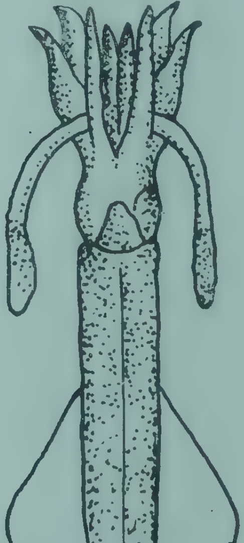

Fig. 5-8 *Loligo edulis* (' kensaki-ika")

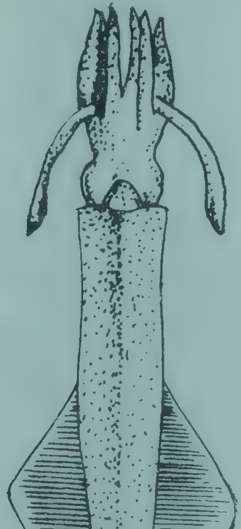

Fig. 5-9 *Loligo bleekeri* ("yari-ika")

Sepia esculenta (ko-ika”), *Sepioteuthis lessoniana* (“afuri-ika”) and *Doryteuthis bleekeri* (“yari-ika).

Among them, “surume-ika” is the most economically important. The length of its body is about 30cm. It is distributed widely along all coasts of the Japanese Islands; especially near Hokkaido, Aomori and Iwate. “Tobi-ika” lives in the tropics and subtropics, e.g. from south Kyushu to the Loochoo Islands. The shape of this species resembles that of “surume-ika”.

“Hotaru-ika” is small in size (about 6 cm) and has luminous bodies in the belly surface of the body. It is found in Toyama and Sagami Bays.

The other species of squids have almost the same length. The cuttle fish has a thick body and a large hard shell, e.g. “ma-ika”, “ko-ika”, “kaminari-ika”.

2. Fishing methods

Squid are caught mainly by hand-angling and pole-angling, or sometimes by set net. There are two kinds of hand-angling instruments: “sokomata” and “tonbo”.

The pole-angling instrument is called “hanego”. This consists of a forked pole and lines, to which hooks are attached.

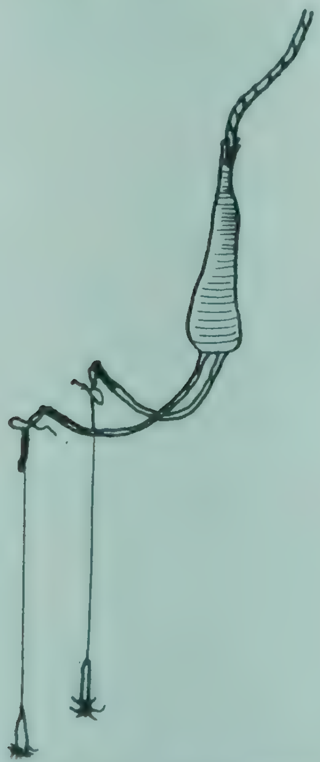

Fig. 5-10 “Sokomata”

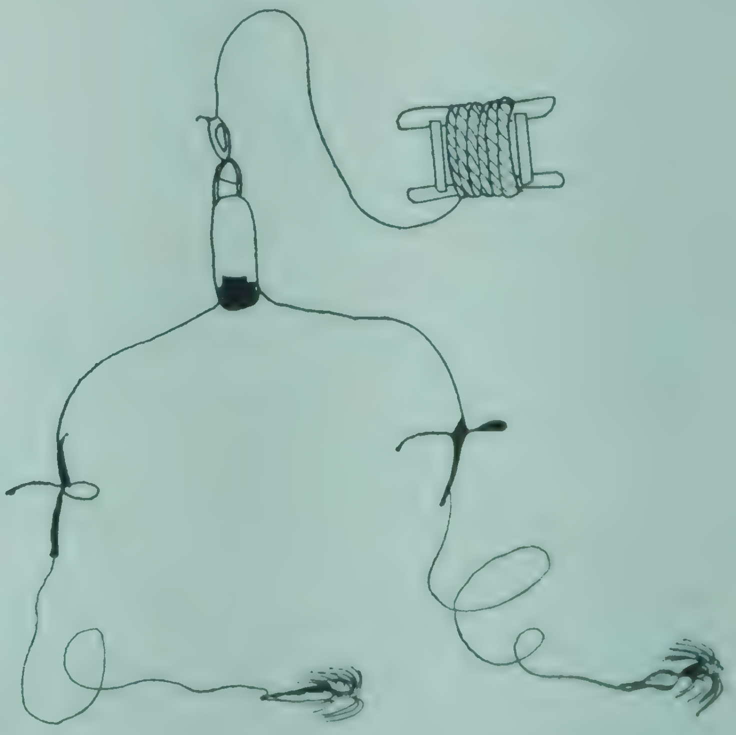

Fig. 5-11 “Tonbo”

3. Kinds of dried squid (“surume”) according to species

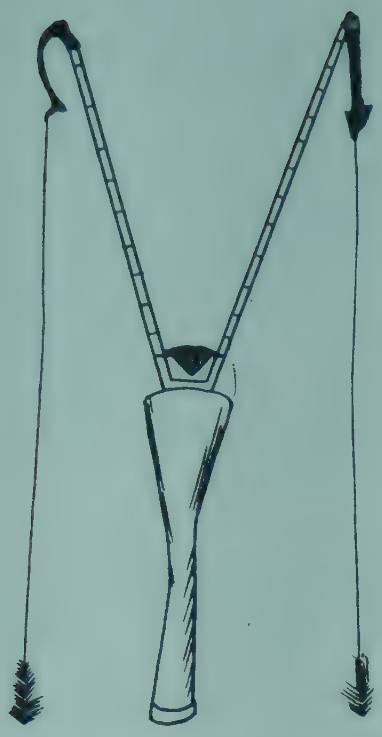

Fig 5-12 "Hanego"

According to the species of the raw material the name of the finished dried squid are different. The names of the finished products and the species of their raw material are shown in Table 5-3.

Also, there are different names for the finished products according to the processing method, e.g. skinned dried squid ("migaki-surume"), moonfaced dried squid ("otafuku-surume"), bag-shaped dried squid ("fukuro-surume"), dried squid having a hole in the end of the body ("biko-surume") and others.

Among them the second grade dried squid ("niban-surume") which is prepared from "surume-ika" (*Ommastrephes sloani pacificus*) is econo-

Table 5-3. Kinds of finished dried squid

Names of dried spuid	Kinds of "surume" (kinds of merchandise)	Raw material
First grade dried squid ("ichiban-surume")	"ichiban-surume" (first grade dried squid)	"Kensaki-ika" (*Doryteuthis kensaki*)
	"Budo-surume" (Grape-shaped dried squid)	Ditto
	"Sasa-surume" (Bamboo-leaf-shaped dried squid)	Small "kensaki-ika"
Second grade dried squid ("niban-surume")	Second grade dried squid ("niban-surume")	"Surume-ika" (*Ommastrephes sloani pacificus*)
Dried squid having shell ("Kotsuki-surume")		"Ko-ika" (*Sepia esculenta*)
"Mizu-surume"		"Afuri-ika" (*Sepioteuthis lessoniana*)

mically the most important because of the large volume produced.

4. **"Niban-surume"**

The processes for preparing "niban-surume" consist of cutting, washing, drying and shaping.

a. Cutting

The belly side of the mantle-cartilage of the squid is split out from the neighbourhood of the infundibulum to a point distant from the end of the mantle-cartilage by means of a knife with the ege held upward. Then the body becomes a flat triangular-shape having a cephalopodium. The ink-sac attached to the visceral mass is removed by hand. Then the visceral mass (of which the great part is liver) is cut off from the muscle part of cephalopodium with a knife and discarded. The head is split at the central line to remove the jaws of the mouth. At this time the transparent tendonous matter (*Sepia esculenta* has a large hard shell) is removed with a knife. A skilled workman can cut 600-700 squid per hour. This should preferably be done before 10.00 A.M. in order that the material may be partially dried the first day.

b. Washing

The cut and split squid are soaked in fresh water for a short time to whiten the surface of the body. They are then washed with sea water or water containing salt (Bé $2^\circ \sim 3^\circ$) to remove mucous and other substances. They are finally washed with fresh water to remove salt in order to prevent absorption of water after drying.

c. Drying

The drying is generally carried out in the sun. It is completed in 3 days when the weather is favourable.

The squid hand on straw-ropes which are stretched between upright wooden poles of wood bar frame construction ("shibori-naya") as shown in Fig. 5-13.

The washed squid are placed on the straw ropes in such a manner that the fin of the body is on one side and the tentacles on the other. Drying is carried on from about 10.00 A.M. to 4.00 P.M., if the weather is fine about 3.00 P.M. two squid adjoining each other are tied together with a tentacle of each. Each two squid thus tied are transfered from

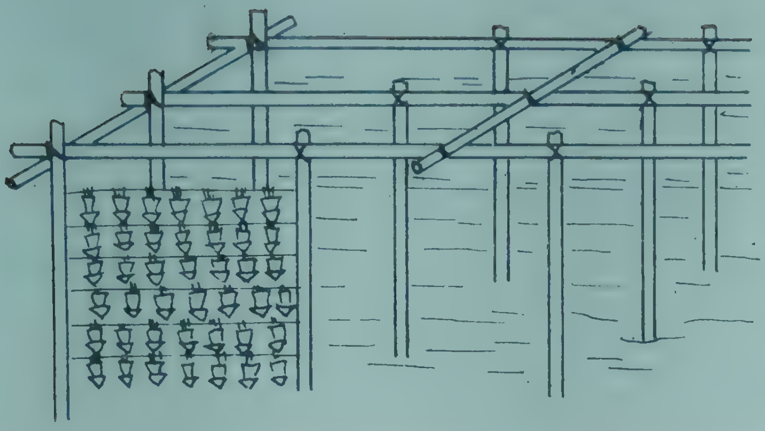

Fig. 5-13 "Shibori-naya"

the straw-rope to rafters (about 4~6 cm dia.) (80 squids each per rafter), which are brought into a hut ("taruki-naya") and are covered with a strawmat before sunset. If the weather is fine next morning, the rafters on which the halfdried squid hang are brought out of doors and the drying is continued. When two-thirds dried, the squid are taken from the rafters, and each is shaped to keep the desired appearance.

Groups of six shaped squid each tied together by their tentacles, are again hung on the rafters. On the third day, if the weather is fine, the drying is completed. In the afternoon, each squid is shaped again and groups of 10 squid each are tied together by their tentacles.

The tied squid are packed into a straw-bag, and exported after inspection and grading by a Government Inspector.

5. **"Biko-surume"**

"Biko-surume" is a dried squid having a hole at the end of the body (neighbourhood of the fin). When squid are being dried, the bodies are thrust through with a thin bamboo spear, so that a hole remains in the dried product. In ancient times, each dried squid having a hole were liked in the Chinese market.

6. **Skinned dried squid** ("migaki-surume")

For the preparation of this product, "Kensaki-ika" (*Doryteuthis kensaki*) is used. They are cut in the same manner as in the preparation of the "niban-surume". After being cut about two tenths of the skin is removed at the end of the body. On the first day the skinned squid is dried in a hut; after the second day the squid are dried on a straw-mat for two or three days. When two-thirds dry, the squid are packed in straw-bags for several days to generate a white powder (this is a mixture of aspartic acids and others) on the surface of the body. After several days, the squid are taken from the straw-bags, and dried on straw-mats.

They are turned several times in a day. Before the drying is completed, the squid are shaped.

7. "Moonface-shaped" dried squid ("otafuku-surume")

This process is almost the same as in preparation of "niban-surume" from "surume-ika" (*Ommastrephes sloani pacificus*) up to point of being half dried. The half dried squid bodies are stretched side ways into a round shape.

8. "Bag-shaped" dried squid ("fukuro-surume")

Bag-shaped dried squid is prepared from "kensaki-ika" (*Doryteuthis kensaki*). The cephalopodium is removed from the body and the skin is removed by hand. The bag-shaped body is turned inside out and the inside surface is washed to remove ink and other substances. The reversed body is hung on the end of a spit, which is stuck into a bundle of straw with 50 squid and dried in the sun.

After drying for a half day, the body is reversed to its normal condition and is further dried. Every day until it is about eight-tenths dried, the body is shaped to make a good appearance. After drying, the squid are packed in a straw-bag for several days. When the weather is fine, the squid are considered to be completely dried when they are removed from the bag.

9. "Mizu-surume"

The body of "afuri-ika" (*Sepioteuthis lessoniana*) is split to remove the visceral mass, and eyes are removed. The skin is then almost entirely removed and the body is stretched on a kite shaped split bamboo frame and is dried.

10. Dried cuttle fish ("kōtsuki-surume")

"Kōtsuki-surume" is prepared from the species of cuttle fish having a large hard shell like a ship. The head and the body are split and the eyes are removed. After being washed the prepared cuttle fish are dried on a bamboo-blind without removal of the hard shell. Large size cuttle fish will be dried completely within 7~8 days.

11. Method of drying

In general, the squid is sun-dried. This provides a simple method for the preparation of abundant amounts of the dried product. When the weather is unfavourable, drying can not be completely carried out and the quality of the finished product becomes inferior. Many means of artificial drying have been devised, e.g. use of coal or charcoal, or infra red light. However, the catch of squid is so abundant at one time that artificial drying is seldom used.

12. Grading of the dried squid

The grades of dried squid from "kensaki-ika" (*Doryteuthis kensaki*) and "surume-ika" (*Ommastrephes sloani pacificus*) are determined according to the regulations of Ministry of Agriculture and Forestry, because they are widely produced through Japan. The grades of the other dried squid are regulated by the respective prefectural authorities in the producing areas concerned.

The grade is based on freshness, appearance, color, flavor, size (weight), and water-content (18～22 %).

13. Technical problems in the preparation of dried squid

There have been many problems encountered in the preparation of dried squid. Tanikawa has studied some of those problems and reached the following conclusions:

a. Blackening of the surface of dried squid(1)

When very fresh raw squid is dried quickly, the surface of the body may exhibit a black discoloration after it is dried. This is called "Asayake-surume" (morming-meat-burn of dried squid).

There are many chromatophores between the first and second layers of the epidermis. The chromatophores have brown and yellow pigments. While the muscle is still active, the chromatophores swell or shrink, but when the muscle becomes inactive, the chromatophores shrink permanently. If very fresh raw squid, of which the muscle is active, have been completely dried at a rapid rate, the chromatophores in the body are also dried in swollen condition. The surface, in which the chromatophores are swollen has a blackish appearance.

To prevent such blackening, very fresh raw squid should be soaked in fresh water in order to make the muscle inactive and to shrink the chromatophores. The squid soaked in fresh water has a white surface and when dried assumes a characteristic amber color.

b. Red discoloration of dried squid(2)

If the squid is exposed to rain during drying, its surface becomes reddish in color. This condition is called "ame-ika" (rainy squid). The reddening is caused by the pigments in the chromatophores flowing out and becoming reddish if the squid becomes alkaline in reaction due to decomposition. Even when squid are held under conditions of high humidity, without rain and at a comparatively high temperature, the surface also becomes reddish. The cause is the same as that of rainy squid meat. This reddish squid is called "mure-ika" (stuffy squid)(3).

The difference between rainy squid and stuffy squid is that in the former the surface is bright owing to the dried mucous substance which was generated by dissolving water soluble protein from the squid meat during rain fall. In order to prevent rainy squid or stuffy squid, the squid should be treated with a preservative accompanied by acetic acid in order to acidify the meat. The squid should be covered with a polyethylene-film cover as a protection from rain.

c. Relation between freshness of the raw material and the quality of dried squid

The limit of freshness of the raw material to make good quality dried squid was found to be 20 mg% of volatile basic nitrogen(3, 4). Tanikawa et al.(4) have presented a table (Table 5-4) showing the relation

Table 5-4. Relation between the freshness of original raw material and the grades of the quality of the dried squid

Grades of quality	Freshness of raw material		The holding time (hrs.) of the raw material after being caught
	Volatile basic nitrogen (mg %)	pH	
First grade	Less than 5～10	below 5.4	within 5 hrs.
Second 〃	about 15	5.4	7～8 hrs.
Third 〃	20～30	about 5.8	24 hrs.
Fourth 〃	about 40	6.0	4.8 hrs.
Fifth 〃	above 50	above 6.0	above 72 hrs.

between the freshness of raw material (V.B.-N mg %) and the grades of the quality of dried squid.

In order to ascertain the freshness of the original raw material after it has been dried, the shape of the chromatophores under the epidermis of the dried squid should be observed under a microscope. If the corners of the fixed chromatophores are sharp, the freshness of the raw squid was good, but if the chromatophores have lost their shape, the freshness was not good.

II. Dried Herring ("migaki-nishin")

1. **Dry-curing**

In Japan, herring is exposed to the wind and air after removal of the visceral mass (including roe or milt) and splitting. This split and dried herring is called "migaki-nishin" (dried herring fillet). For over a hundred years "migaki-nishin" has been produced in large quantities. However, with the decrease of the catch (67,920 tons in 1968), the production of this staple article of commerce decreased to 10,760 tons in 1968. This number includes the product which was manufactured from the imported raw herring from U.S.S.R. Spring herring ("hashiri-nishin") is used as raw material. Two methods of preparation are employed: (1) The back meat fillet method; and (2) the side meat method.

2. **Procedures for making "migaki-nishin"**

a. Back meat fillet method (old method)

Twenty herring from which gill, roe, milt and other visceral mass have been removed, are tied together by straw rope passed through the gill slits to the mouths, they are hung over a wooden bar and dried for 2～3 days. Then the back bone is removed from the caudal fin to the head. Next, the belly flesh is cut off horizontally along the lower line of the back bone. The dressed fish is then dried for 2～3 weeks by air drying. Thus, three parts, namely back flesh, belly flesh and back bone, are obtained. The back flesh is called "migaki-nishin" (cut-off meat). The back flesh to which the back bone attached are called "do-nishin" (body meat), and are used for feed or fertilizer. The gill and visceral mass are dried and called "sasame-kasu", which is used for fertilizer. The milt is also dried for fertilizer. The roe is dried and used as a food. The dried roe is called "kazunoko", and has been an essential food for New Year's day celebrations from ancient times in Japan.

b. The side meat method (new method)

The herring taken from the wooden bars after 2 days' drying are filleted on both sides of the back bone. Thus two side fillets (left and right) are obtained from a herring body.

3. Kinds of dried herring

There are three kinds of dried herring in Japan according to the moisture-content of the dried product; One-third dried, half-dried and completely dried herring, with the moisture contents of about 45～60% after 4～5 days' drying. 35%after 20 days' drying and below 22% after one month's drying, respectively.

4. Grading

Good quality dried herring is distinguished by the firmness of the meat, glossy color of the skin, and presence of scales on the skin. Poor quality is distinguished by fatty and soft meat, by the presence of a mucous substance on the skin, and a rancid odor.

III. Dried Herring Roe ("kazu-no-ko")

After removal from the body the herring roe are soaked in a tank of sea water for 4～5 days in order to remove the blood and increase firmness. The roe which have remained in herring body for 4～5 days after it is caught have already solidified in the body. Therefore it is sufficient just to wash such solidified roe in sea-water. The solidified roe are spread on a bamboo mat and washed with a shower of fresh water. After drainage, the roe are air and wind dried on a straw mat for about a week. After drying, the small pieces of roe are removed by hand and the large and good-sized pieces are packaged. The yield of dried herring roe is 2～2.5% of the weight of the raw herring, and about 20% of that of the raw roe. The production of dried roe was 106 tons in 1968. Therefore, the price of the dried herring roe is high in comparison with other foods.

The quality of dried herring roe is judged by its color, shape, and size. Good quality dried roe is yellow in color, of characteristic shape, about 6 cm in length and above 5.6 g in weight. The smaller sizes are given an inferior grade. Poor quality is distinguished by the presence of a moldy odor. The cause of such moldy odors may be attributed to the use of unfresh herring roe or "stuffying" by rainfall during the drying process.

IV. Dried Sardines

There are many kinds of *Clupeidae* and *Engraulidae* in Japan. Of the sardines (*Clupeidae*), there are: herring ("nishin", *Clupea pallasi*), Sardine ("ma-iwashi", *Sardinia melanosticta*), round herring ("urume-iwashi", *Etrumeus micropus*), *Stelephorus japonicus* ("kibinago"), *Sardinella zunasi* ("sappa"), *Ilisha elongata* ("hira"). To the *Engraulidae*, belong the *E. japonicus* ("seguro-iwashi") and anchovy ("katakuchi-iwashi", *Anchovia indicus*). The catch of sardines in 1936 amounted to 1,570 thousand tons, but has decreased to 458,130 tons in 1968. Among the sardines, sardine ("ma-iwashi"), round herring ("urume-iwashi") and anchovy ("katakuchi-iwashi") are air dried in Japan. The production of dried sardines was 1,233 tons in 1968. The small anchovy is dried and is regarded as a palatable dish. Boiled-dried sardines are also prepared for consumption by the domestic market.

The dried anchovy ("tazukuri") is processed as follows: Small anchovy, 6～9 cm in length, are washed in fresh water. After the washing, the fish are spread on straw mats for wind drying, being turned over several times in a day. At night the rolled straw blinds in which the anchovy are held are brought into a house. The drying may be finished in several days. The yield of dried anchovy is about 20～30% of the weight of the raw material. The small sardine ("ma-iwashi") is also dried similarly to the dried anchovy.

V. Dried Cod and Alaska Pollack

Cod ("tara", *Gadus macrocephalus*) and Alaska pollack ("sukeso-tara", *Theragra chalcogramma*) are caught abundantly near Hokkaido, in the Bering Sea and the northern Pacific Ocean. In 1968 the catch of cod and Alaska pollack was 1,715,495 tons.

Cod and Alaska pollack are wind and air dried making dried round cod, cod stomach, Alaska pollack and pollack stomach. The dried round Alaska pollack is called "mintai" in Korea, where it is dried by repeated freezing during winter nights and thawing under winter day light. This is classified as a type of frozen-dried product. The process will be described later.

1. Dried round cod ("bō-tara")

Cod are beheaded, eviscerated and the back bone is removed; the fish then are dried in the sun until they becomes as stiff as sticks. They should be dried to a moisture content of less than 30%. The production of dried cod including dried Alaska pollack was 4,283 tons in 1968.

2. Dried cod stomach

Cod stomach, gullet and gills are removed connceted as they are and dried. This product is exported for China. Good quality is distinguished by large size and a reddish brown color of the dried gill, and amber color of the stomach. Gills from unfresh cod are of whitish grey gills color when dried. The production amount is small.

3. Dried round Alaska pollack

This product is prepared in the same manner as cod.

VI. Dried Shark Fin

Dried shark fins are mainly used in Chinese dishes. There are two kinds of dried shark fin; white dried shark fin and black dried shark fin. The former is prepared from the fins of *Carcharhinus gangeticus* ("mejiro-same") and *Cynias manazo* ("hoshisame"). The latter is prepared from the fins of *Isuropis glauca* ("aosame"), *Prionace glauca* ("yoshikiri-same") and *Heterodontus Japonicus* ("neko-same"). The Chinese like white fins more than black fins. From one shark one dorsal fin, two pectoral fins and one caudal fin are obtained. The quality of the caudal fin is superior to that of the pectoral fins. The production of dried shark fin in Japan was 1,456 tons is 1968.

Dried shark fin is prepared as follows: Each fin is cut carefully off from the base, avoiding the attachment of the meat as much as possible. The cut fins are washed in sea water or dil. NaCl solution with a scrubbing brush, and are then washed in fresh water. A hole is bored in the bony part of each fin with gimlet. Cotton string is passed through the hole. Fins are hung by the string from a high wooden bar and dried in the air for about 2~3 weeks. The yield of dried fins is 1~2% of the total weight of the shark body, and 30~40% of that of the raw shark fin.

VII. Other Dried Shellfish and Mollusc

Hard clams and octopus are also air and wind dried, but the production is small.

VIII. Dried Laminaria ("konbu")

1. Introduction

Dried laminaria is one of the most important dried foods in Japan and is considered as an important article of the diet. The Japanese eat not only the dried laminaria after seasoning, but also use it as stock after extraction by hot water. The taste of dried laminaria is mainly due to sodium glutamate. Sodium glutamate for seasoning is manufactured recently commercially from tha hydrolyzate of wheat.

Laminaria is a kind of brown algae inhabiting the cold sea currents. The main places of its production are Hokkaido, the Kurile Islands, and Sakhalin. Hokkaido accounts for 90% of the total production. The production of the raw laminaria was 169,874 tons in 1968. There are many kinds of laminaria produced in Japan: true laminaria ("ma-konbu", *Laminaria japonica*), Rishiri Island laminaria ("Rishiri-konbu", *L. ochctensis*), "Rishiri-enaga-ori-konbu" (or "Rausu-konbu") (*L. longipes*), narrow lamina laminaria ("hosome-konbu", *L. religiosa*), Mitsuishi district laminaria ("Mitsuishi-konbu", *L. angustata*), long lamina laminaria ("naga-konbu", *L. angustata var. longissima*), thick lamina laminaria ("atsuba-konbu", *L. coriacea*), long stype laminaria ("kukinaga-konbu", *L. longipedalis*), fragile lamina laminaria ("yayan-konbu", *L. fragilis*), giant laminaria ("oni-konbu", *L. diabolica*), curly edge laminaria ("chijimi-konbu", *L. cichoriaides*), thick lamina laminaria ("kagome-konbu", *Kjellmaniella crassifolia*), muscous laminaria ("tororo-konbu", *K. gyrata*), forked stem laminaria ("nekoashi-konbu", *Arthrothammus bifidus*) etc. (The capital letters of Japanese names of laminaria indicate place names.) The distribution of laminarias is different according to the species, as are also the collecting methods.

The collecting season starts in mid-July and continues until about the end of November in Hokkaido. The methods of collection are (1) long wooden poles having a hook which are used for deep sea laminaria, (2) long handled scythe which is used for shallow sea laminaria; and, (3) long pole having a wooden hook, which is used for laminaria grown at about 4 fathoms depth. After being collected by one of these methods the laminaria are hauled to the boat-side with a hook and are cut off at the roots with a sickle. Two or three years old laminaria is considered to be mature. Those less than one year old are called "mizu-konbu" (first year laminaria fronds), and are not collected from the sea.

The laminaria once taken from the sea should be dried in a short time. A good quality product is obtained only from raw well matured laminaria dried in good weather at a good drying-yard. Such a drying-yard is a place which is exposed to the sun for much of the day, has gradual slope and is covered with small stones or coarse sand.

2. **Drying**

The collected laminaria are cut at the root, and the lamina are dried by being hung on many lines. The fronds are turned over carefully once a day in the afternoon in order to equalize the drying without twisting. At evening the roughly-dried lamina are gathered, brought to a hut and are covered with straw matting to equalize the moisture-content. The next morning, the lamina are dried to completion in the drying-yard. In good weather the drying may be finished in one or two days.

3. Grading and inspection

The quality of laminaria is graded by color, size of lamina, the presence of scratches, its dried condition, etc. The best quality is brilliant darkish brown or dark greenish brown in color which is characteristic of laminaria which have been completely dried in one day. The dried lamina should be broad thick and of uniform size and without winlkes and scratches. Laminaria which were not completly dried in a day or two are characterized by the presence of winkles and a white powder.

4. Styles of dried bundled laminaria

There are several styles or shapes of the finished products prepared from the dried lamina: (1) dried lamina bound at the base of the lamina ("motoyoroi-konbu"); (2) dried lamina folded ("ori-konbu"); (3) long-cut dried lamina ("nagakiri-konbu"); (4) bound rod-shaped dried lamina ("bokonbu"); and (5) poor quality dried laminaria

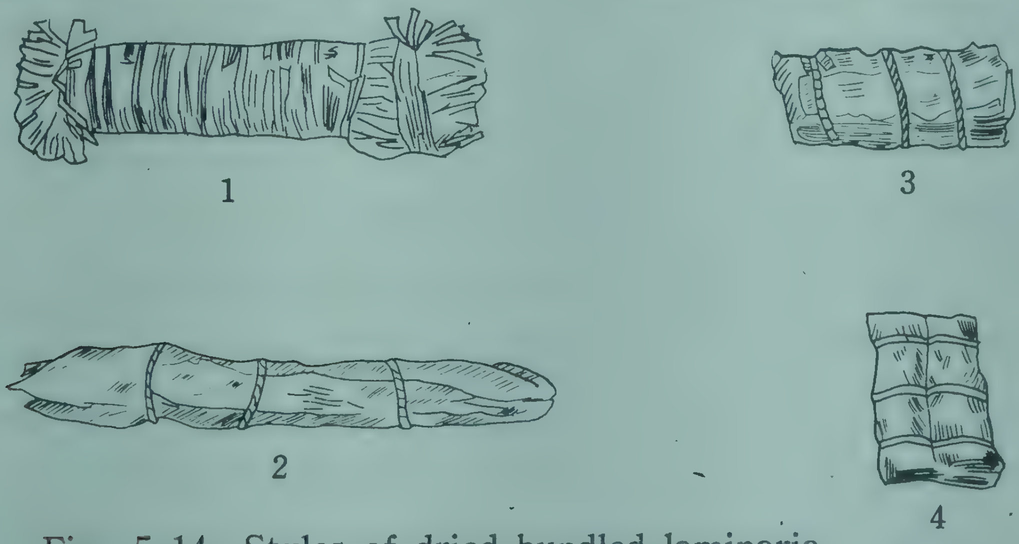

Fig 5-14 Styles of dried bundled laminaria
1. "nagakiri-konbu"
2. "motozoroi-konbu"
3. "ori-konbu"
4. "hashiori-konbu"

("zatsu-konbu").

Dried lamina bound at ends of lamina ("motozoroi-konbu") is that style in which the base of the lamina of dried laminaria is cut crescent-type and the lamina are bound being arranged each end (see Fig. 5-14-2). The product is prepared from "makonbu" or "Rishiri-enaga-oni-konbu" ("Rausu-konbu"). Dried lamina folded ("Rausu-konbu"). Dried lamina folded ("ori-konbu") is that style in which the dried lamina are folded to a definite length, piled up and tied at three places with straw rope or laminaria rope which is made from waste laminaria (see Fig. 5-14-3). This style is prepared from "ma-konbu", "Rausu-konbu", "Rishiri-konbu", "Mitsuishi-konbu". Long cut dried lamina ("nagakiri-konbu") is that style in which the dried lamina are cut in lengths of 105 cm and then piled up and tied (see Fig. 5-14-1). This material is prepared from "ma-konbu", "Rishiri-konbu", "Mitsuishi-konbu", "hosome-konbu", "yayan-konbu", "chijimi-konbu", and others. Among the others, "naga-konbu" produced in Kushiro was famous as an export to China before World War II; it is tied with laminaria rope. Bound rod-shaped dried lamina ("bo-konbu") is that style in which dried lamina are cut in lengths of 30, 45 or 60 cm and combound with straw or laminaria rope. Poor quality dried laminaria ("zatsu-knobu") consists of various kinds of dried laminaria of inferior quality in respect to the style of product described above. These poor quality dried laminaria are tied by combining in the same manner as "nagakiri-konbu". The short sizes are packed in straw bags. The total production of dried laminaria amounted to 33,336 tons in 1968.

5. Utilization of dried laminaria for food

As a brief classification, the dried laminaria are used for (1) plain dishes, (2) stock-making, (3) processed laminaria. The palatability differs by species and places of production.

a. For plain dishes

As plain dishes, "Mitsuishi-konbu" is used, because it is easily cooked well and becomes soft on boiling; the taste is good. "Naga-konbu", "kukinaga-konbu", "Atsuba-konbu" are next in popularity to "Mitsuishi-konbu".

b. As soup-stock, "Rishiri-konbu", "ma-konbu" and "Mitsuishi-konbu" which have respective merits, are excellent. Among them "Rishiri-konbu" is the best. The stock made from "Rishiri-konbu" ("nagakiri"-style) is transparent, and it has a refined taste.

c. For processing, almost all kinds of laminaria are used, especially with the improvements in processing technique. Among the many processed products of laminaria there are: Laminaria-cake, laminaria-tea, "tororo-konbu", vinegared laminaria, laminaria-powder, rolled laminaria ("konbu-maki"), "tsukuda-ni", etc.

IX. "Nori" (or laver) Industry

1. **Importance**

The "nori" industry is one of the most important enterprises in the fishery industry. "Nori" (or laver) is prepared from *Porphyra tenera* Kjell, a kind of red algae. Dried "nori" is prepared by making thin sheet from raw crushed laver and drying them. "Nori" which is called "Asakusa-nori", has been considered a first-class dish from ancient times in Japan. "Asakusa-nori" is also called "kuro-nori" (black dried laver). In earliest times, natural *Porphyra* only was used as the raw material, but with the increase in demand, *Porphyra* has been cultivated at many places. In 1968, 2,871,536 thousand sheets of dried nori are produced annually. Besides *Porphra tenera, P. yezoensis* ("susabi-nori") has also been cultivated in Japan. This algae is used to prepare "asakusa-nori".

Monostroma sp. ("hitoe-gusa"), *Enteromorpha sp.* ("ao-nori") and *Ulva* are used to prepare "ao-nori" (green dried laver). *Porphyra* and other species are mixed to prepare "maze-nori" (mixed eried laver). The production of "ao-nori" prepared from the other species besides *Porphyra* amounted to 164,068 thousand sheets (356 tons) in 1968.

The production of natural *Porphyra* occurs in Hokkaido, Miyagi and Shimane Prefectures. Cultivated *Porphyra* is produced in Iwate, Miyagi, Chiba, Tokyo, Kanagawa, Aichi, Mie, Okayama, Hiroshima, Yamaguchi, Tokushima, Ehime, Fukuoka, Kumamoto and Oita Prefectures. Other species besides *Porphyra* are also cultivated in Chiba, Aichi, Mie, and Ehime Prefectures, but such species grown naturally are collected mainly in Chiba and Ehime Prefectures.

2. Cultivation of "Nori" (laver) in Japan

In almost all regions *Porphyra* appears in January when the sea water temperature has become low enough to meet its requirements. The "nori" prepared from *Porphyra* collected at this time is called new "nori". From the root which remains after the first collection, *Porphyra* grows luxuriantly during the winter months, forming reproductive cells. At this time *Porphyra* are collected for preparation of dried "nori". *Porphyra* disappears completely in the spring when sea water temperatures become warmer. The cultivation ends at this time.

Porphyra reproduces by means of microscopic one-celled spores which are shed by the thousands from each plant. If these spores come in contact with a rough surface, they may lodge against it; if the surface is in the intertidal zone, germination occurs and a new plant soon appears. Since the great majority of *Porphyra* spores fail to encounter a suitable surface, the abundance of adult plants can be increased if additional surfaces for spore attachment are provided in water where spores are prevent.

In Japan, many rows of bamboo or branches of other trees which are bound with straw rope (they are called "soda-hibi", and have been employed from the eariliest time), or horizontal rope nets tied to stakes (these are called "ami-hibi", and were invented in 1927) are used to provide suitable attachment surfaces for the spores. Bamboo blinds are also employed. Those are horizontal blind tied to stakes. They were used in Korea before World War II. Recently, floating bamboo brush and floating rope nets have been practically employed. The former was invented in 1929, and the latter in 1946. These forms of attachment surface, placed in the water in mid-September just before the season's first plants appear, are soon covered with *Porphyra*.

Cultivation of "nori" in Tokyo Bay originated in the 1670's, but was not widely practiced until about 1800. As early as 1901 over 2,000 acres of ocean floor were used for growing *Porphyra*, but in 1962 more than 7,829 acres were cultivated only by sticks placed in sea bottom.

3. Preparation of dried "Nori"

Harvesting of "nori" (laver) begins each year in November or December (new "nori") and successive harvests are made as often as growth permits until April, when growth ceases and the remaining plants degenerate.

Harvesting is done by hand from a small boat (called "beka"). Fresh raw "nori" is carefully washed with sea water in a bamboo basket, pounded to remove impurities and then washed again with fresh water. After drainage, the fronds are cut fine on a chopping board with two knives, one in each hand. About 3.6 kg of small pieces of cut fronds are put in about 54 litres of fresh water in a tank, and mixed homogeneously. The suspended pieces of fronds mixed with water are put on a blind having frame of definite area. The pieces of the fronds in the frame, which remain on the blind after drainage, are dried in the sun avoiding strong wind and are made in the form of thin sheets (10 sheets are produced in one frame). First the inside surface is exposed to the sun and then the frame is reversed to expose the outside surface. The best quality "nori" is jet black in color and lustrous when dry. Half of the total production of dried "nori" is produced along the shores of Chiba Prefecture in Tokyo Bay.

The sheets of "nori" are usually marketed in an air-tight metal container, because they are hygroscopic. "Nori" is a breakfast stand-by, although it is often served at other meals, in Japan. One popular preparation is "rolled rice balls ("makisushi"), in which vinegared rice, vegetables, and mashed fish meat ("soboro") or cooked egg are rolled in a sheet of "nori" which is then sliced into servings. "Nori" is also eaten after cutting the sheets into small squares and warming them over a charcoal fire. One side of the square is then dipped into a flavoured soy bean sauce ("shoyu") and then eaten with steamed rice. The chemical composition of dried "nori" is as follows: moisture about 16%, protein 25~30%, carbohydrates 7~18%. It contains vitamins, A, B, C and D. The content of vitamin C is up to 140 mg per 100 g of fresh weight. It is also a good dietary source of iodine, required for normal function of the thyroid gland.

4. Processed "Nori"

The dried "nori" used for preparation of several kinds of processed foods.

a. "Tsukuda-ni-nori" (seasoned "nori" paste)

The sheets of dried "nori" are crushed and soaked in seasoning juice made from "shoyu" and sugar over night, and then boiled slowly with the juice in a pot over a fire.

b. "Yaki-nori" (roasted "nori")

The sheets of dried "nori" are cut into small squares and roasted in an oven.

c. "Ajitsuke-yaki-nori" (seasoned and roasted "nori")

Small squares of the dried "nori" sheet are seasoned with seasoning juice, and then dried again.

X. "Wakame" (dried Undaria) Industry

1. Importance

Undaria pinnatifida ("wakame") has been eaten in soy bean paste soup ("miso-shiru") from ancient times. The volume of production is next to that of laminaria. It amounted to 69,675 tons in 1968. "Wakame" is found only along the shores of Japan where the effects of warm sea currents are felt. In the Japan Sea, it grows from Kumamoto Prefecture to near Soya strait (between Hokkaido and Sakhalin), and on the Pacific shores from Miyazaki Prefectur to Muroran in Hokkaido, but it does not grow in Kagoshima, Kochi, or Wakayama Prefectures where the warm current occurs but the temperature is too warm.

"Wakame" is produced into two kinds of products. One of them is the desalted and dried Undaria ("shio-nuki-wakame") and the other is the salted-dried Undaria ("shio-boshi-wakame"). The former is famous as so-called "Naruto-wakame", but the latter is produced in only small quantity, The amount of production of the dried Undaria ("wakame") amounted to 13,985 tons in 1968. According to desalting methods, there are several kinds of desalted-dried Undaria. The desalting methods vary according to the districts of production. For example, "Naruto-wakame" is prepared in Naruto district by desalting in plant ash and "yunuki-wakame" is prepared in Tokushima Prefecture by soaking in hot water. In addition to *Undaria pinnatifida, Alaria crassifolia* ("Ezo-wakame", "sarumen") is prepared for dried "wakame", but the latter is inferior in quality to the former.

2. **Preparation of dried Undaria** ("hoshi-wakame")

a. "Naruto-wakame"

"Naruto-wakame" has long been produced from Undaria in the Naruto strait district near Kobe, but with increased demand a large quantity of Undaria is collected from other places of production in Japan, especially from Miyagi and Iwate Prefectures, and is processed as "Naruto-wakame" at Naruto.

Ten to 13 kg of fresh Undaria, of which the fronds are immature are placed on a straw mat. About 5 litres of not completely burned ash of half-blackish color, which has small amount of potassium, is scattered on the mat. The Undaria fronds are thoroughly mixed by hand with the ash. The fronds coated with ash are sun dried on a beach. When they are one third dried, the midribs of the fronds are removed by tearing lengthwise, and they are brought to a hut for storing. After the ash-coated fronds have been washed in sea water and then in fresh water for a short time to remove the ash completely, the fronds are dried out of doors hanging from straw rope. During the drying the fronds are split between the midrib in order to straighten them. After being taken from the straw rope the inferior quality fronds are removed. They are then dried again on a straw mat. After drying, the fronds are folded in 30 cm lengths and are packaged in cellophane bag or wooden or paper boxes. The yield is about 6～8% of the weight of the raw Undaria.

b. "Yunuki-wakame" (dried Undaria desalted in hot water)

Two or 3 fronds of Undaria are put in boiling fresh water until the color turns to green in order to desalt, and are then put quickly into cold water. The midrib is removed lengthwise by hand and the fronds are dried outdoors hanging from straw rope in the shade. This processing gives a smaller yield than that of "Naruto-wakame". Another defect is that it is difficult to keep the green color for a long time.

c. "Ita-wakame" (Dried plate Undaria)

After washing in fresh water, the Undaria fronds are placed side by side to form a sheet on a blind made from miscanthus, and are placed to dry on a straw mat on the beach. The midribs of the fronds are not removed, thus differing from "Naruto-wakame". The sheets are bundled together and tied with paper tape. This dried Undaria is crushed by hand and sprinkled over steamed rice for eating.

d. Other processing

There are many other variations processing in the various places of production. For example, "sudare-boshi-wakame" (dried Undaria on blind), "shibori-wakame", etc.

XI. Preparation of Dried "Funori"

1. **Importance**

The red algae, *Gloiopeltis furcata* ("fukuro-funori") is another important seaweed in Japan. "Funori" is the Japanese name applied to the dried, partially fermented, bleached raw material, from which is obtained a viscous nongelling colloid that is completely soluble in warm fresh water. It is widely used for a number of industrial purposes in Japan. There are many "funori" producers in Japan, centering around Osaka, and who collect the raw material from many places of production in Japan.

Gloiopeltis which is produced in northern Japan is large in size (*G. furcata var. coliformis*). That which is produced in southern Japan is thin (*G. f. var. intricata*). *Gloiopeltis* grows on rocks in shallow sea water along the Pacific shores of Japan from Hokkaido to Kyushu. The main places of production are Hokkaido, Iwate, and Nagasaki Prefectures.

2. **Dried "Funori"**

The collection procedure is as follows: Long handled rakes are manipulated from boats or divers gather the seaweed by hand. Collectors sell crude, dry *Gloiopeltis* to factories where it is cleaned, moistened, and redried on straw mats. At the same time the color is bleached. This treatment causes the plants to stick together by their own cohering property, so that they form thin sheets which are easily rolled up after the final drying. The finished product is often marketed in rolls about 3 feet long and 6 inches in diameter. Processing of "funori" is done during the summer months, coinciding with the collecting season.

Besides *Gloiopeltis furcata, Gloiopeltis tenax* is also used as raw material for "funori". This species forms excellent raw material, but the yield is less than that from *G. furcata.* In addition to *Gloiopeltis* two or more species of the genera, *Irideae* ("ginnan-so") and *Chondrus* ("tsunomata") are also used, but these are inferior in quality to the former, therefore the prices are lower. Processing of these plants is similar to that of *Gloiopeltis,* but may involve steaming and soaking to render them more pliant and to facilitate their dissolution when used.

Dried "funori" is used after dissolution instead of starch in laundering, as a sizing for paper and fabrics, in the preparation of water-base paints, as an adhesive for plastering and as a hair-dressing.

BOILED-DRIED PRODUCTS

Raw marine products (animal or plant) are boiled in order to destroy their enzymatic activity and to remove fatty substances; then dried by natural or artificial drying methods. In Japan there are many kinds of products which are boiled and dried. Products prepared by such methods are important and before World War II, the products were mainly exported to China. Processes used in preparation of boiled-dried products are described below in the order of their volume of production.

I. Boiled-Dried Sardines ("niboshi-iwashi")

Sardine ("ma-iwashi", *Sardinia melanosticta*) and anchovy ("katakuchi-iwashi", *Anchovia indicus*) are used for boiled-dried products as well as for canning. The production of boiled-dried sardines including anchovy was 52,371 tons in 1968. The main places of production are Iwate, Miyagi, Fukushima, Ibaragi, Chiba, Shizuoka, Mie, Hyogo, Wakayama, Tottori, Shimane, Hiroshima, Yamaguchi, Tokushima, Kagawa, Ehime, Kochi, Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, and Kagoshima Prefectures. The reason why there are many places of production in Japan is that sardines are caught along almost all the shores of the above mentioned prefectures of Japan. Boiled-dried sardines are used mainly for preparing soup stock ("dashi").

Sardines or anchovies about 10 cm in length are washed in water to remove the scales and impurities. The washed fish are placed in a row on "seiro" (steaming basket) of which the bottom is made from bamboo. A stack of 13~17 baskets are placed in boiling salt water in a large iron pot by means of a hoist. The salt water is made by adding 1~1.2 kg of salt to 20 litres of water. Boiling is continued until the fish floating (about 15 minutes). After the boiling, the fish are drained by tipping the baskets. They are then completely dried on straw mats for 2~3 days. The dried sardines are packaged in paper bags or boxes according to size and quality.

II. Boiled-Dried Sand Lance ("niboshi-ikanago")

Sand lance ("ikanago", *Ammodytes personatus*) has many different names according to the places of production. "Ikanago" is a name popular in Hanshin district. The sand lance is small fish having length of 15 cm, and lives along almost all shores of the Japanese Islands. This fish is used mainly for boiled-dried products. "Tsukuda-ni" (seasoned fish) is prepared from the boiled-dried sand lance.

The total catch of sand lance was 150,473 tons in 1968, and the boiled-dried products amounted to 8,345 tons in the same year. The main places of the production of the boiled-dried sand lance are Hokkaido, Miyagi, Shizuoka, Aichi, Mie, Hyogo, Okayama, Kagawa and Fukuoka Prefoctures. The processing of the boiled-dried sand lance is almost the same as that for boiled-dried sardine. The yield is 15~20% of the weight of the raw fish.

III. Boiled-Dried Abalone ("Hoshi-awabi")

1. Introduction

Abalone ("awabi", *Haliotis*) is also prepared in the boiled-dried form as well as canned. There are several species of *Haliotis*. The total catch of abalones was 6,141 tons in 1962, and the amount of the dried product was 85 tons. The main places of preparation are Hokkaido, Iwate and Nagasaki Prefectures. *Haliotis discus hannai* ("Ezo-awabi") inhabits the sea near Hokkaido. In Nagasaki, Mie, Chiba, and Miyagi Prefectures *Haliotis gigantea* is found. In olden times, the dried abalone prepared from "madaka" *Haliotis gigantea* or "megai" *Haliotis sieboldi*) in Miyagi, Chiba, Mie and Nagasaki Prefectures was of amber color and was called "meiho" (amber color dried abalone). The dried abalone prepared from "kuro-awabi" (*Haliotis discus-discus*) or "Ezo-awabi" (*Haliotis discus hannai*) in Hokkaido in olden times was grey in color and it was called "kai-ho" (grey dried abalone). On the surface of the grey dried abalone a quantity of a white powder is found The "mei-ho" commands a higher price than "kai-ho".

2. Preparation of dried abalone

a. "Mei-ho" (amber color dried abalone)

The body meat is removed leaving the visceral mass behind in the shell and avoiding injury to the lamella (gill). After selecting the individual bodies by size, 3.75 kg of abalone meat of large size are salted with 360 g of salt for 2～3 days. The salted abalone is washed carefully with fresh water in a tank, and finally the surface of the body is washed with a scrubbing brush. The washed abalone are placed in a boiling basket, which is heated in a pot. After boiling, the basket in which abalone are placed, is soaked in hot water of 50°C which was made adding cold water to the boiling water. They are heated slowly for 1～2 hours until the meat become so soft that a straw can be put throughit. After the heating, the abalone in the boiling baskets are dried in the shade for about one hour, and then they are roasted over a charcoal fire at about 70°C; next they are dried again in the shade. If the abalone are of large size, next day the dried abalones are boiled in boiling water for 20～40 minutes. Thus roasting and drying are repeated alternately for 5～10 days. On the last day only drying is done. Large abalone must finish drying within one month, and the small abalone needs a half month.

b. "Kaiho" (grey dried abalone)

The processing of "kai-ho" (grey dried abalone) is the same as that for "mei-ho" as above described. The raw material of "kai-ho" is abalone of small size, so that the boiling is done once, and then roasting and drying are repeated for a half month. After the material is 70～80 % dry, the dried abalone are put in a straw bag for one week in order to equalize the water-content in the meat. Then the abalone are removed from the bag and mold germinated on the surface is brushed off. They are dried in the shade for two or three days and are put in the straw bag again for one week. Thus, when the drying and placing in straw bag are repeated alternately, the surface of the dried abalone meat becomes covered with white powder.

c. Simple process for dried abalone

The processing method as above described and which have been carried on from very early times are troublesome. A simplified process is carried on in Miyagi Prefecture. The processing is as follows : Abalone meat, from which the visceral mass was removed, are salted for 3～7 days. After washing the salted abalone meat they are boiled in a flat pot for 5 minutes. The boiled abalone are dried for 7～10 days.

IV. Boiled-Dried Sea Cucumber ("iriko")

1. **Introduction**

Boiled-dried sea cucumber in addition to boiled-dried abalone has been an important export product. That having many large papillae is called "yushi-san" (dried sea-cucumber having papillae) ; it is prepared from true sea-cucumber ("namako") (*Stichopus japonicus*). The variety which has no papillae is called "ko-san" or "mushi-san" (dried sea cucumber without papillae). This product is prepared form "janome-namako" (*Holothuria argus*), "kurohoshi-namako" (*Pstsdyivhopud nigripunctatus*), and "kin-ko" (*Cucumaria japonica*). "Namako" inhabits almost all shores of the Japanese Islands from Sakhalin to Kyushu. "Janome-namako" is found near the Okinawa Islands, and "kurohoshi-namako" occurs in the same localities as "namako". "Kinko" inhabits the cold sea water northwards from Miyagi Prefcture to Sakhalin. The catch of sea cucumber including all the kinds was 13, 203 tons in 1968.

2. Boiled-dried sea cucumber

The living sea cucumber is placed in fresh water for as short time in order to clean the intestinal tract. The intestine from the anus is removed carefully in dilute. salt water by a deviscerating apparatus ("daccho-kan"), and the abdominal cavity is cleaned with a thin brush, and drained. The prepared sea cucumbers are put into salt water of Bé 3°, of which the temperature is lowered to 95°C from boiling, and are boiled for 1~1.5 hours. During foilng, if the bodies swell by the expansion of air in the abdominai cavity they are deflated by piercing with a needle or gimlet. After boiling, the sea cucumbers are taken from the hot water. Adhering foam is removed by means of a spatula-like implement. They are then placed in a basket and their shapes straightened. After cooling, the bodies are roasted at 70° C, and dried in the shade for 5 days. The dried sea cucumbers are put in a straw bag for 2~3 days in order to equalize the moisture content, and are then dried again for 2~3 days. The yield is 5 % of the weight of raw sea cucumber.

3. Grading

The best quality of dried sea cucumber is bright blackish brown in color, has many sharp papillae and is not skinned. The dried sea cucumber having white powder coated on the surface of the body is of inferior quality. Tanikawa(5)(6) has studied biochemical properties of sea cucumber in detail.

V. Boiled-Dried Cartilage

Boiled-dried cartilage ("meikotsu") is prepared from the cartilage of shark, "manbo" (*Mola mola*), "ei" (*Raja sp.*). The product has been exported to China for many years. Cartilage of the jaw, fin and head of these fish are cut in 7~9 cm lengths and are soaked in hot water to remove the attached meat. The prepared cartilage is boiled again, and is then dried in the sun. The cartilage is of amber color after drying. Dark brown material is inferior in quality.

VI. Boild-Dried Shellfish Ligament

The big ligaments of shellfish, such as scallop ("hotategai", *Pecten vessoensis*), "itaya-gai" (*Pecten laqueatus*), "taira-gai" (*Pinna pectinata japonica*) are used for the preparation of boiled-dried foods. The scallop ligament commands the highest price. It was exported to China before World War II. The areas of prodution of scallop are Hokkaido and Aomori Prefectures ; those of "taira-gai" are southern Honshu - Shimane, Saga, Fukuoka and Kagoshima Prefectures ; those of "itaya-gai range from Hokkaido to Kyushu Island. The production of boiled-dried ligament was 129 tons in 1968.

Boiled-dried ligament is prepared as follows : Fresh scallop is put into boiling sea water for a short time to open the shell and the body is removed. The mantle and visceral mass are separated from the body to obtain the ligament. On the other hand, if it is desired to remove the ligament from the shell in the raw condition it is opened with a knife. The ligaments are placed in a boiling basket, which is put into boiling sea water or salt solution (1.4 kg of salt in 20 liters of water) and boild for 20 minutes. After the boiling, ligaments are put in another basket, which is placed outdoors to dry for about a week. Sometimes the boiled ligaments are dried over a charcoal fire for a short time and then are dried in the sun. The yellowish white dried ligaments are considered to be superior in quality. These ligaments are called "white dried ligaments". The yield of the dried ligament is 3.5～5.0 % of the raw shellfish with shell.

Ligaments which are dried with the mantle and visceral mass are called "black dried ligaments". The preparation of the "black dried ligaments" is as follows : The shellfish bodies are boild and then are smoked to dry ; cotton string is run through ligaments from one to another, and they are then dried. The yield of "black dried ligament" is 7.5～8.5 % of the raw shellfish with shell.

VII. Boiled-Dried Shellfish Meat

Boiled and dried meat is also prepared from shellfish whose ligament is small, such as "agemaki" (*Sinonovacula constricta*), oyster ("magaki", *Ostrea gigas*), "tori-gai" (*Cardium muticum*), "aka-gai" (*Anadara* (*Scapharca*) *inflata*), "mate-gai" (*Solen gouldi*), hard clams ("hamaguri", *Meretrix meretrix lusoria*), short necked clams (or baby clams) ("asari", *Venerupis philippinarum*), hen clams ("hokki-gai", *Mactra sachalinensis*) and mussel (*Volsella sp.*). The dried "agemaki" and dried mussel were important products exported to China.

The preparation of boiled-dried shellfish meat is as follows : The shellfish is boiled in sea water to open the shell and the meat is removed. The meat is then boiled in sea water again to increas its firmness. It is dried in the sun.

VIII. Dried Shrimp

Marketable dried shrimp consist of "peeled dried shrimp", and shrimp dried in the shell. Species of shrimp of commercial importance in Japan include ; "shiba-ebi" (*Metapenaeus joyneri*), "kuruma-ebi" (*Penaeuls japonicus*), "tenaga-ebi" (*Palaemon nipponensis*), "sakura-ebi" (*Sergestels luceus*). The main places of production of dried shrimp are in southern Japan : Hiroshima, Yamaguchi, Fukuoka and Saga Prefectures. The amount of raw shrimp caught in 1968 was 68,025 tons, and the production of boiled-dried shrimp was 3,748 tons. The best known place of production is Isahaya in Nagasaki Prefecture. Two styles of peeled shrimp are prepared. One is "peeled dried shrimp" ("muki-ebi”) which is prepared from *Penaeus japonicus* and is of the best quality ; the other shrimp from which shell is removed after drying, “shrimp peeled after drying” (“suri-ebi”).

1. **Shrimp peeled after drying** (“suri-ebi”)

The species of raw material for this product are *Metapenaeus joyneri*, *Palaemon nipponensis*, *Sergestes lucens* and *Pasiphaea sivado*. The shrimp are washed and boiled in large kettles. To each kettle of water (about 20 liters) about 360 g of salt are added. After the weter has been brought to a boil, the shrimp are dumped in, about 4 kg to each kettle. They are then boiled for 30～40 minutes until the bodies become curved. When the shrimp have been boiled for a sufficient length of time, they are dipped from the kettle onto a bamboo-blind, and dried. The heads and shell of the dried shrimp are separated from the meat by various means. The simplest process is heating the dried shrimp with a bamboo or wooden stick.

Recently the meats have been mechanically separated from the waste material. The mechanical device used in Japan is a barrel-like arrangement having many revolving short levers. When the meats of shrimp are separated from the shell, they loose their color during prolonged storage. Thus the dried shrimp should be stored in the shell until prepared for market and use.

2. **Dried peeled shrimp** (“muki-ebi”)

Penaeus japonicus is used mainly as raw material for preparation of this product. The heads and shell are removed from the meat by hand and the meats are boiled and dried. The quality of this dried shrimp is considered to be the best.

3. **Dried shrimp with shell** (“kawatsuki-ebi”)

Dried shrimp with shell are prepared from *Metapenaeus joyneri*, *Penaeus japonicus*, *Palaemon nipponensis* and *Sergestes lucens*.

The process is the same as that for shrimp which are peeled after drying as described above. The difference between the two products is that in this case the shrimp are not peeled. The best quality of any kind of dried shrimp is the product which is light red in color, of good curve-shaped and of uniform size.

IX. Dried Shark Fin-Rays

Shark fins are prepared not only for plain-dried fins, but also as dried fin-rays. By boiling shark fins to remove the epidermis naked fin-rays are obtained. The fin-rays dried under in the sun are called "dried shark fin ray" ("taishi"). The preparation of the dried shark fin-rays requires skill. In Japan, as the production of plain-dried shark fin is more profitable than that of dried shark fin-rays, the production of the latter is small and is carried on in Ibaragi, and Chiba Prefectures. The best quality dried shark fin-rays are light white in color and have no gelatinous substance on their surface.

The preparation of dried shark fin-rays is as follows : Shark fins removed from the fish bodies are soaked in fresh water to soften for 4～5 days. After becoming soft, the fins are heated in hot water of 90°C for 20～30 minutes to swell and to remove the epidermis. The cartilage at the base of the fins is cut off to be used separately for "dried cartilage". From the base to the central part the fin-rays are separated by removing the gelatinous substance which present between the fin-rays with bamboo spatula keeping the fins at a warm temperature by dipping into or taking out from hot water. The fin-rays which are pressed by half-split bamboo to keep the base fin-rays unseparated, are dried in the sun. Broken dried fin-rays are pasted together with gelatine made from the shark fin epidermis ("gesshi"). The pieces of fin-rays are called "shisai" ; there are two kinds of "shisai" ; white or black "shisai".

BROILED-DRIED PRODUCTS

Broiled-dried fish are prepared in general for the purpose of short time preservation. Thus, this is a provincial product and the volume of production is small. Broiled-dried fish may consist of sea-bream, flat fish, sardine and other fish.

The broiled-dried sea bream is rather a special product of Shizuoka Prefecture. The process of preparing broiled-dried sea-bream is as follows: The scales on the surface of the fish are first removed and then the visceral mass is removed through the gillslit. Eviscerated fish is then washed with fresh water. One end of a bamboo stick is pierced from mouth to gillslit. The opposite end of the bamboo stick is stuck into the ash in a fire box and the fish is broiled over a charcoal fire. After the broiling, the fish is dried on a drying shelf.

Broiled-dried sardine is prepared as follows: Small fish such as sardine are broiled near a charcoal fire and are then dried. After drying the bamboo stick is removed from the fish. Other fish are also prepared as broiled-dried foods by the same process.

SALTED-DRIED PRODUCTS

Dried-salted fish is also an important product among the dried products in Japan. The amount produced was 134, 845 tons in 1968. The important dried-salted fish are sardines, pompanos (jack mackerel), saury, mackerel, cod, Alaska pollack and others.

I. Dried-salted Sardines

In every place where sardines are caught in Japan, dried salted sardine are also processed. "Ma-iwashi" (*Sardinopus melanosticta*) and round herring ("urume-iwashi", *Etrumeus micropus*) are used for the preparation of dried-salted product. There are three kinds of dried-salted sardines according to method of preparation : round-drying, split-drying and pierced-drying. The amount of production was 26, 808 tons in 1968. The main places of production are Ibaragi, Chiba, Toyama, Shizuoka, and Kyoto Prefectures.

Dried-salted sardines are processed as follows :

1. **Round-drying**

The round herring ("urume-iwashi") makes a product superior in quality to that obtained from the sardin (e"ma-iwashi"). Raw sardines are placed in a basket and washed in a sea water tank. Fifteen to 16 kg of the washed fish plus about 15 % of salt are put into a barrel until the fish are covered with water. The fish in the barrel are stirred two or three times. An alternate method consists of putting the raw sardines into a salt solution of Bé 15°. The salting continues 6~8 hours. After salting, each 10 fish are pierced from mouth to gillslit with a bamboo stick and dried in the air. The yield of the round dried-salted sardine is 20~30 % of the raw sardine by weight

2. Split-drying

Split-drying is employed to prepare the dried-salted product from the round herring ("urume-iwashi"). If sardines (ma-iwashi") are employed as the raw material those of low fat content are preferable. The fish bodies are split at the ventral or dorsal side, and gills and visceral mass are removed. After having been washed, the fish are soaked in a salt solution of Bé 15°~18°, or they are dry-salted over a night with 20~30 % of salt. The salted fish are washed with fresh water and placed skin-side down on a bamboo blind and dried in the air. When the fish are two-thirds dried, they are turned over to continue until comletely dried.

3. Pierced-drying

A bomboo stick is pierced through the eyes of sardine or from gillslit to mouth. The former process is carried on in Chiba Prefecture, and the latter in Kyushu. As raw material sardine or anchovies are used. After the fish are washed with fresh water, they are soaked in salt solution of Bé 6°~7° for 4~5 hours. The salted fish are pierced with a bamboo stick through the eyes, or from gillslit to mouth. The pierced fish are dipped in fresh water to wash, and are hung from wooden bars to dry for 5~6 days. The dried fish are packaged each 5 sticks in a bundle.

II. Dried Salted Pompanos (Jack Mackerel)
("Shio-boshi Aji")

Pompanos which are caught abundantly in Japan are also salted and dried. The amount of production of dried-salted pompanos was 37, 199 tons in 1968.

There are two kinds of dried-salted pompanos ; dried-split and pierced-dried. Splitting is carried on more often on the ventral side of the fish than on the dorsal side in Japan. The visceral mass is removed from the split fish, and they are washed with fresh water. After washing, the fish are dry-salted over night, and then are dried on a bamboo blind. The yield is 50～70 % of the raw fish by weight. Pierced-dried pompanos are prepared by the same procedure as that for sardines in Kyushu.

On Oshima Island near Izu Penninsula, from ancient times, "Kusaya-no-himono" (fermented in brine and dried scads, a kind of pompanos) has been prepared. The "kusaya-no-himono" is a rather special product and production is limited. Scad (*Decapterus muroadsi*) are used as the raw material. The brine in which the scad are salted, is used over and over again, and contributes a speacial putrefactive odor. When ever the fish are put in the brine, salt is added little by little. The fish are soaked in the brine over night. The next day, after draining the brine, the fish are dried in the sun. The special odor is liked by some people.

III. Dried-Salted Saury and Mackerel

Dried-salted saury and mackerel are prepared as described above for sardines. In 1968 the production of dried-salted saury was 10, 071 tons and that of mackerel was 21, 076 tons. The main places of production of the former are Ibaragi, Chiba, Tokyo, Shizuoka, Mie, Kyoto, and Hyogo Prefectures and chiba and Shizuoka Prefectures in the case of mackerel.

IV. Dried Cod

Salt-dried cod is an important item of merchandise in the world. The processing method is differs from nation to nation. In Japan, cod (*Gadus macrocephalus*) is abundantly caught in the northrn parts, Hokkaido and Aomori Prefectures. The cod is split, salted, and then dried in the sun. The amount of production of dried cod was 1,782 tons in 1968. The main place of production is Hokkaido.

The processing of dried cod in Japan is as follows : Raw cod is split at the dorsal side, and the visceral mass is removed. The fish is washed with fresh water to remove the black membrane of body cavity.
In old Japanese processing the head was not removed. The split cod is salted in brine or with dry salt. When brining is employed, split cod is soaked in salt solution of Bé 18° which was boiled and then cooled. At this time, cod are piled on each other in an empty tank and the brine is added. After two days soaking, the brine is renewed, and fish are pressed with a plate, on which stones are placed for 1 day. The next day the brinned fish are placed to dry on a bamboo blind. When dry-salting is employed, split cod are piled on each other with a sprinkling of fine salt between each two layers. The amount of salt is about 190~200 kg for 1,000 split fish. The salting continues 10 days. After salting the fish are washed with salt solution of Bé 4° and are placed on a bamboo blind to drain. After draining, the fish are dry salted again in tank. After washing the surface of the salted fish with fresh water the fish are again dried on a bamboo blind.

V. Dried Cod Fillet ("suki-mi")

Cod or Alaska pollack fillets are dry-salted or salted in brine, and dried. The amount of production of dried cod and Alaska pollack fillets was 9,986 tons in 1968. The place of production of dried cod or Alaska pollack is Hokkaido. After fish are filleted, the fillets of cod or Alaska pollack are skinned. Before filleting, head, bone and fine are removed. The salting is carried on as the same way as employed for dried round or split cod.

The dried cod or Alaska pollack fillets are used for domestic consumption. They are softened in water and then seasoned with "shoyu" and sugar before eating.

VI. Dried Mullet Roe ("karasumi")

Mullet (*Mugil cephalus*) roe is prepared as dried mullet roe ("karasumi"). Sometimes "sawara" (*Scomberomorus niphonus*) roe are also prepared as the dried mullet roe. The places of production are Nagasaki, Wakayama and Shizuoka Prefectures.

The processing of dried mullet roe in Japan is as follows : The unbroken roe bags containing the roe are placed in tubes where they are either sprinkled with salt or soaked with brine. About 6 kg of salt are added to each 50 kg of eggs. Too much salt will cause the egg sacks to break. After the roe have remained in the salt or brine for 10 to 12 hours, they are drained and piled on a wooden board. A weighted wooden plate is placed on top of them. Then next day the roe are spread on a bamboo blind in the sun to dry. They are taken into a hut for pressing each night and the next day they are again dried. After the drying process reached the half way point, the roe are dried only in the sun. During fair weather the drying process requirs about 20 days. A finished product of amber color and which is large in size is preferable.

VII. Dried-Salted Yellowtail ("enkan-buri")

Yellowtail ("buri, *Seriola quinqueradiata*) is not only used as a daily dish, but also as canned fish or dried-salted fish. The kinds of dried-salted yellowtail include big yellow-tail ("enkan-buri"), small yellowtail ("enkn-inada"), small yellowtail fillet and yellowtail bound with straw. The name of the yellowtail product is different according to its size, the big is "Buri", and the small one is "Inada". The amount of production is small, because the annual catch is only 80, 140 tons in 1968, and most of them are used fresh. The places of production of dried-salted yellowtail are Miyazaki, Kagoshima, Fukui, Ishikawa, Tottori and Kyoto Prefectures.

1. **Dried-Salted yellowtail** ("enkan-buri")

The visceral mass and gills are removed from fresh big yellowtail by splitting the ventral side. After being washed with fresh water, several lines of half-cuts are made on the surface of the fish body in order to allow salt to penetrate easily into the meat. The dressed fish is then soaked in dilute salt solution to remove blood and other extraneous from the meat. For each barrel 10 big yellowtail are added with a sprinkling of salt to the amount of 15～16 kg. After the salting for 4～5 days, the fish are washed with fresh water and are dried in the sun. Sometimes the big yellowtail are split from the dorsal side, and then are salted and dried.

2. **Dried-salted yellowtail bound with straw** ("waramaki-buri")

This is a special product of Toyama and Ishikawa Prefectures and is prepared as follows : After the head is cut off, the visceral mass is removed from the split ventral side of fresh big yellowtail. The dressed fish are washed with fresh water and filleted. About 22 kg of salt are added to each 10 fish (20 fillets). After dry-salting for about one week, the fish are washed with fresh water. Each fillet is cut lengthwise into two pieces. The pieces are hung for 1～2 weeks in the shade to dry. Fat which appears on the surface of the meat is removed rewith a bamboo spatula. The surface of the fish meat is covered with a thin layer of baked salt or rice-bran (1 kg) to which salt (500 g) is added. Each fish meat piece is wrapped with Japanese paper, then with straw and at last is bound tightly with straw rope. At the top of the rope, a small loop is made for hanging. Sometimes the bound fish is smoked to prevent oxidation.

3. **Dried-salted small yellowtail**

Small yellowtail (less than 30 cm length) is also salted and dried in Hokuriku district.

The head of the fish is cut diagonally above the eyes to the throat and the fish is then filleted after removal of visecral mass and gills. Each fillet is partially skinned. On the skinned meat 3 or 6 half-cut lines are drawn. After the skinned fillet is washed in dilute salt solution, about 500 g of salt is added to each two fillets (one fish) in a barrel. After 1~1 1/2 days of the salting, the fish fillet is dried in the sun for 7~10 days. The dried fillets are then packed 50 to a box.

FROZEN-DRIED PRODUCTS

Alaska pollack are frozen outdoors during winter nights ; the water in fish meat evaporates after being thawed in the sun in the day time, and drying is completed by repeated freezing and defrosting. These frozen-dried fish are called "mintai" in Korea. Frozen-dried Alaska pollack ("mintai") is processed in Hokkaido.

Agar-agar is also a frozen-dried product. The gelatinous substance extracted from sea-weeds is repeatedly frozen and thawed to complete the drying. Agar-agar is produced mainly in Nagano, Gifu, Osaka and Hyogo Prefectures. The amount of production was 4, 093 tons in 1968.

I. Frozen-Dried Alaska Pollack ("mintai")

The ventral side of Alaska pollack is split to remove the visceral mass. Each 10 fish are bound together through the gillslit and they are soaked in fresh water to remove blood and to let the meat absorb sufficient water, the water being changed 4~5 times a day for 2 days. After this soaking, the bound fishes are hung from wooden bars outdoors to freeze completely. The frozen fish are always placed outdoors in order to be dried by repeated freezing and defrosting. When the drying is 80 % complete, the bound fish are piled up on each other to the height of 1 meter and are covered with straw mat for 3~4 days to equalize their moisture-content. In good weather, the bound fish are hung from wooden bars and dried outdoors. It requires about 70 days to complete the drying.

II. Agar

1. The agar industry in Japan

Dehydrated agar such as one can see today is said to have been made by a certain Japanese about 300 years ago. His discovery led to the establishment of a business and the enterprise grew rapidly to an industry in Japan. Prior to World War II the Japanese held virtually a world monopoly on the product. Agar is now processed in California, North Carolina and Florida in the U. S. A., Russia, Australia, South Africa, China, Mexico, Indonesia, Malaya, etc.

Agar is prepared from extractive from "ten-gusa" (*Gelidium amansii Lmx.*) mixed with other species boiled in water. The extractive is solidified to a gel ("tokoro-ten") by cooling. The gel is cut into bars. These bars are then placed outdoors to dry by repeated freezing and thawing. In the Orient, agar has been an important part of the diet. Production of agar in Japan has risen steadily since its origin, especially from 1926 until 1940. During the war years there was a sharp decline. From 1926 until about 1933 over 75 per cent of Japan's agar production was exported. After 1932 home comsumption increased at a much greater rate than exports, which actually declined from 1936 through 1945. In 1946 exports rose again along with production. Amounts of production for 1960 through 1968 are given in Table 5—5. The United States has been one of the heaviest buyers of Japanese agar. Except for the war years, the amount exported to the U. S. A. has increased as new uses were developed. In addition to the U. S. A., Japanese agar is also exported to other countries; South Vietnam, Thailand, Malaya, Philippines, Singapore, Burma, India, U. K., Holland, France, West Germany, Italy, Czechoslovakia, etc.

2. Kinds of agar

The agar processed by the conventional method is called "natural agar" in Japan. There are two kinds of natural agar: "kaku-kanten" (square rectangular shaped agar) and "hoso-kanten" (strip string-shaped agar). Agar is now processed by machines by mass-production methods regardless of season and weather. It is called "industrial agar" (or "scientific agar") in Japan. There are several kinds of industrial agar: "kona-kanten" (powdered agar), flake agar, granular agar, net work agar and "hoso-kanten" (strip string-shaped agar), etc. The industrial agar has so many special shapes that it is also called special agar.

Table 5-5. Agar production and exports in Japan

Year	Production (1,000 tons)	Amount of export (1,000 tons)	Amount of domestic use (1,000 tons)
1960	2,393	724	1,669
1961	2,946	506	2,440
1962	2,232	470	1,762
1963	2,453	417	2,036
1964	2,138	589	1,549
1965	2,573	715	1,858
1966	2,825	547	2,278
1967	2,929	700	2,229
1968	3,025	1,106	1,919

3. **Raw material for agar**

Raw material for the agar industry in Japan is obtained from the entire coastline of the main island of Honshu. Of the thirty or more species of seaweeds utilized, "ten-gusa" (*Gelidium amansii Lmx.*) is by far the most important. Other widely used species include "Ō-gusa" (*Gelidium pacificum Okam.*), "hira-gusa" (*Gelidium subcostatum Okam.*), "oni-gusa" (*Gelidium japonicum (Haiv.) Okam.*), "himeta-ten-gusa" (*Gelidium divaricatum Martens*), "hai-ten-gusa" (*Gelidium pusillum (Stackh.) Lejol.*), "ego-nori" (*Camphylaephora hypnaeoides J. Agardh.*), "ogo-nori" (*Gracilaria verrcosa (Hudson) paper fuss*), "igisu" (*Ceramium rubrum J. Ag.*), "tori-noashi" (*Acanthopeltis japonica Okam.*). In Sakhalin Island "itani-gusa" (*Ahnfeltia plicata Fries*) was employed as the main raw main raw material. With the main raw material, "ten-gusa" (*Gelidium amansii*), other species such as "ego-nori" (*Camphylaephora hypnaeoides*), "ogo-nori" (*Gracilaria verrcosa*), "Tori-noashi" (*Acanthopeltis japonica*), "igisu" (*Ceramium rubrum*), "oni-gusa" (*Gelidium japonicum*), and "hira-gusa" (*Gelidium subcostatum*), etc. are mixed as subsidiary materials. To obtain a high quality agar, the suitable species of seaweeds should be selected and a standard ratio of the mixture of various selected seaweeds should be employed. For example, *Gelidium amansii* 45%, *Ceramium hypnaeoides* 10%, *Gracilaria verrucosa* 15%, *Ceramium rubrum* 5%, *Gelidium subcostatum* 10%, is a good mixture.

"Ten-gusa" (*Gelidium amansii*) is harvested from April to September. The seaweeds are pulled from the substratum by hand or by means of special rakes, "jyoren". The quality of "ten-gusa" gathered by women divers is the best, that pulled by "jyoren" next. That came ashore is the poorest in quality. According to the places of production, "ten-gusa" produced in the Shima district in Mie Prefecture is considered the best, while that produced in Izu district and Wakayama Prefecture comes next.

4. Bleaching

The freshly gathered seaweeds are spread to dry on bamboo racks along the shore. Partial bleaching occurs if the seaweeds are sprinkled with fresh water, or are rained upon after they have been once dried. Therefore, the gathered seaweed is artificially "bleached" after drying by sprinkling with fresh water at the shore. Bleached seaweed is used in Nagano Prefecture, but it is not liked in Kyoto and Osaka Prefectures.

5. Processing

Dried seaweed bleached or unbleached is transported from coastal areas to processing plants. A batch to be extracted is soaked in cold water in outdoor concrete vats to effect bleaching and cleaning. In bleaching, shells, mud and calcareous incrustations attached to the seaweed are removed at the same time. According to the kinds of finished agar, the ratios of the mixed "ten-gusa" and other species are different. For example for square rectangle-shaped agar, "ego-nori" is added to "ten-gusa" to the amount of 30%, and for strip string-shaped agar, "ego-nori" is added to "ten-gusa" to in 40%. The desired mixture of various seaweeds, about 75kg of the dried seaweed, is placed in tank of boiling water (about 3400 liters) heated by a brick firebox in which wood is burned. When the water again comes to a boil, sufficient acetic acid or sulfuric acid is added to bring the pH just to the acidic side of neutrality (about pH 6.0). The amount of acetic acid or sulfuric acid added to raw seaweeds is shown as in Table 5-6.

Table 5-6. Amounts of acetic or sulfuric acids added to the raw seaweed

	For 3.75kg of raw seaweed			Proportion to the amount of water	
	Amount of acid	Percent of acids	Amount of water	Raw seaweed(%)	Acid (%)
Acetic acid	20 g	0.60 %	10 liters	4.3	0.0324
Sulfuric acid	12.4g	0.33 %	10 liters	4.3	0.0132

After an hour or two of boiling, those seaweeds which yield a soft gel in water are added to the mixture and the batch is simmered for another 12 hours. When cooking is finished, the solution from a second extraction of a previous batch is added. In Hyogo Prefecture, all the raw seaweeds are put into a kettle for boiling and when the boiling point is again reached, the batch is simmered with occasional agitation for another 10 hours. Next 240~260 liters of water are added to the batch, which is boiled again, and is filtered. The method of filtration differs according to the places of production. The hot extraction is poured into straining tanks that have perforated bottoms and are lined with a straining cloth of about 20 meshes per linear inch. The filtered liquid runs into a collection tank from which it is again dipped and poured into shallow wooden trays, holding 14 liters each, to solidify. The solidified extractive (gel) is called "tokoroten". A rake-type knife ("tokoro-ten"-cutter) is used for cutting the gel into bars. The sizes of the "tokoro-ten" (gel) cut are shown as in Table 5-7.

Table 5-7. Sizes of the cut gel

Kind of Agar	Length	Width	Thickness	Weight
Square rectangle-shaped agar	30 cm	3.9 cm	4.2 cm	563 g
Strip string-shaped agar	30	7.6	4.2	1088

The bars of "tokoro-ten" may also be cut into strings with a screen. The number of strings is about 200 from one bar of "tokoro-ten" (gel).

The residue after the filtration is called agar-less, which is mixed with the first extraction.

The bars or square rectangle-shaped gel pieces are then placed outors to freeze and thaw. By repeated freezing and thawing dehydration kes place. When hydrophilic colloids are subjected to freezing tem- eratures, the force of hydration is broken and the water held by the olloidal agar particles separates from them in the form of ice crystals. the case of those colloids in which hydration takes place at low tem- erature, hydration or reabsorption of the separated water will occur lmost as fast as the ice melts and there will be little or no final sepa- ation of free water. In the case of agar, however, full hydration or he formation of a colloidal solution occurs only when the temperature s 80°C (176°F), or more. Thus, when the ice in agar has melted, ost of the water involved in the solution runs off. With an agar gel of one or two per cent concentration 70 to 80 per cent of the water is lost in freezing and thawing. With this water, as it runs off, go 70 to 80 per cent of the soluble salts and pigments that were in the original agar solution. Thus freezing and thawing are a most efficient means of purification and dehydration.

6. Industrial agar

Industrial agar (scientific agar) processed by various machines and types of equipment can be produced regardless of the season and the weather. The processing consists of freezing the extractive of seaweeds in a freezing chamber, and then pressing it with a hydraulic press to dehydrate the gel. Industrial agar (scientific agar) can be produced with uniformly homogenous good quality. The processing of industrial agar is as follows:

a. Raw material

The raw seaweeds for industrial agar are almost the same as those of natural agar. In the factories in which pressing is employed to dehydrate the agar, only "ogo-nori" treated with alkaline solution is used. For industrial agar raw seaweeds such as "ten-gusa", "ogo-nori" or "ego-nori" are generally used. Therefore, the blending of species is restricted in order to yield a high gel strength.

b. Washing

For washing, twisting machines or laundering machines are used.

c. Boiling

For the boiling of "ten-gusa" an autoclave is used, and for "ogo-nori" treated with alkaline solution use is made of a kettle which has equipment for circulation of the extractive and filtration equipment of the residue. The kettle is heated with steam. In an autoclave, the heating time for seaweeds is less than that required in the processing of natural agar.

d. Filtration

Filtration is carried on by means of a centrifugal machine.

e. Solidifying and shaping gel

Solidification of the gel is now carried on by means of an endless belt type soldifier which is cooled by water. A cutter attached to the solidifier. Various shapes of gel are made by this process.

f. Dehydration of gel

The gel is frozen in a freezing chamber or in ice making brine tank and is then dehydrated with a hydraulic press.

g. Thawing of frozen gel

Thawing is carried on in the sun or by placing the frozen gel into water.

h. Drying of gel

The drying is done in the sun or in a dryer with a current of heated air. Rarely an infra red ray lamp is employed.

i. Quality of industrial agar

The residue content of industrial agar is less than that of natural agar. The industrial agar is of homogeneous good quality in each lot of product. Further, the gel strength of the former is higher than that of the latter.

7. Yield of agar from raw seaweeds

The yield of the finished product from seaweeds is almost always expressed as a percentage of the air-dry weight of the raw material. The raw material usually contains from 10 to 20 per cent moisture when it is ready for processing. Different species of seaweeds yield different amounts of phycocolloid. In general, those that produce a soft gel yield considerably higher amounts than those seaweeds that produce agar of high gel strength. The range of yield of the finished product rom commercially used species runs from 15 to 80%, or more. The ield of the principal raw material, "ten-gusa" (*Gelidium amansii*), anges from about 20 to 35%. Part of this rather wide range arises rom the seasonal variation in agar content and in part from the efficincy of extraction in the process used. Where a yield of 45% is obtained y a careful laboratory analysis of a raw material, the factory yield of the same raw material may be only 25%, sometimes less. A commercial process never extracts all the agar from the raw material; the yield obtained ordinarily represents an optimum with respect to the cost of production. The optimum is established by the efficiency of the production process.

All seaweeds probably vary with the season in phycocolloid content. According to Aoki(7), in Japan *"Gelidium amansii"* has the highest agar content in the spring and lowest in summer when most of the harvesting is done. In general, the phycocolloid content is done. In general, the phycocolloid content is the greatest during or immediately after the season of most rapid growth. This varies among species and with locality as well.

8. Inspection and grading of agar

The finished agar is inspected for grading by a Prefectural Inspection Station ("Seihin-kensajo") according to the regulation of the Ministry of Agriculture and Forestry for domestic use, while agar for export is inspected and graded by a Governmental Export Inspection Station ("Yushutsu-kensajo"). That is to say all agar produced in Japan is inspected and graded by either a Prefectural Inspection Station or a Governmental Export Inspection Station. The grading of agar is done on the basis of moisture-content, color, gel strength, insoluble matter, protein content, solubility, and other characteristics. Gel strength, according to the official method, is determined by placing a 1.5 per cent solution of agar in a cup (4×6×30 cm, 600 cc) and allowing it to stand to gel for 15 hrs. at 20°C. A gram weight having a cylindrical, flat tip 1 square centimeter in area is placed upon the surface of the gelled agar. If the tip does not rupture the gel surface, the weight is increased by means of adding additional weights. The maximum weight, under which the tip penetrates from the surface of the agar to a depth of 1 cm in 20 seconds, is its gel strength. The time of penetration varies according to the temperature of the gelled agar. If the estimation is made for gelled agar of which the temperature is not 20°C, the penetration time is corrected by the following Table 5-8.

According to the Regulation of the Ministry of Agriculture and Forestry, the square rectangular agar for domestic use is graded into "Superior", "No. 1" "No. 2" and "No. 3". The strip string shaped agar is graded into "No. 1", "No. 2" and "No. 3". The special agar is graded into "Superior", "No. 1", "No. 2" and "No. 3". The exported agar, strip string shaped agar, bundled strip agar and square agar are graded into "No. 1", "No. 2" and No. 3"; and scrap agar into Grade A and B.

Table 5-8. Correction table for the penetration time other than 20°C to that at 20°C

Temperature of the gel (°C)	15	16	17	18	19	20	21	22	23	24	25
Coefficient	0.86	0.89	0.91	0.94	0.97	1.00	1.03	1.06	1.09	1.13	1.16

(Note) The limit of experimental error is considered to be ± 20 g/cm^2.

Table 5-9. Japanese Export Standard for Agar (A) Strip agar-agar

Grade / Item	No.1	No.2	No.3
Color	White and lustrous or milk-white and somewhat lustrous. However, very slightly yellowish or blackish agar-agar is allowed.	White or milk-white agar-agar, tinged with yellow, red or black, however not to remarkable extent.	Agar-agar tinged with light yellowish brown or reddish brown.

The Japanese Export Standard for agar is shown in Table5-9.

Shape		1. Easy in stretching or handling each strip smoothly and separately 2. Free from deformed strips, but few broken ones.	1. Mostly easy in stretching or handling each strip separately. 2. Some deformed or broken strips are allowed.	1. Difficult in stretching or handling each strip separately with some strips mutually sticking to. 2. Deformed or broken strips are allowed.
Uniformity		1. Completely free from impurity, Hanayake (A), Kibari (B), Dankan (C), or Shibi (D). 2. In case of pressed ones, free from clear strips on the side or end. 3. Free from any impurities.	1. Retaining slight impurity. Hanayake, Kibari, Dankan or Shibi. However, mixture within 30% of good quality Sukiura (E) is allowed. 2. Free from any impurities.	With Kibari, Shibi or Dankan remaining. However, mixture within 10% each of superior Kamani (F) and Funazoko (G) is allowed.
Jelly strength	K	350 g/cm^2 or more	250 g/cm^2 or more	150 g/cm^2 or more
	Y	300 g/cm^2 of more	200 g/cm^2 or more	100 g/cm^2 or more
Moisture		22% or less	22% or less	22% or less
Crude protein		1.5% or less	2% or less	3% or less
Unmelting residue in boiling water		2% or less	3% or less	4% or less

Note : The meaning of the foregoing Japanese words is given below :

(A)	Hanayake	Both ends of strip or square agar-agar colored with a pigment and impure constituent of raw seaweeds.

(B)	Kibari	Agar-agar colored with a pigment and impure constituent of raw seaweeds.
(C)	Dankan	Yellowish red agar-agar, the agar-agar element of which is decomposed, because of gelidium jelly remaining uncoagulated for a long time to warm temperature.
(D)	Shibi	Agar-agar presenting an external appearance something like a collection of many opaque bubbles of milk-white, on account of unseasonable weather conditions.
(E)	Sukiura	Inferior portion of agar-agar removed at the time of careful selection.
(F)	Kamani	Low-grade agar-agar produced by reboiling residue remaining after the extraction of agar-agar through boiling raw seaweeds.
(G)	Funazoko	Low-grade agar-agar made from jelly remaining at the bottom of the box used for coagulating jelly.

(B) Bundled strip agar-agar

Grads Item	No. 1	No. 2	No. 3
Color	White and lustrous or milk-white and somewhat lustrous. However, very slightly yellowish or blackish agar-agar is allowed.	White and milk-white agar-agar not remarkably tinged with yellow, red or black.	Agar-agar tinged with light yellowish brown or reddish brown.
Shape	1. Satisfactorily uniform in shape of strips. 2. Free from deformed strips, but few broken ones.	1. Mostly uniform in shape of strips. 2. Containing some deformed or broken strips.	1. Not sufficiently uniform in shape of strips and with strips mutually sticking to. 2. Containing deformed or broken strips.
Uniformity	1. Retaining slight impurity,Hanayake,	1. Retaining slight impurity,	1. Retaining Kibari, Shibi and

		Kibari and Shibi, however completely removed off Dankan. 2. Not remarkably clear strips on the end. 3. Almost free from any impurities.	Hanayake, Kibari, Shibi or Dankan. 2. Containing very small quantities of impurities.	Dankan. 2. With a little impurities.
Jelly strength	K	350 g/cm² or more	250 g/cm² or more	150 g/cm² or more
	Y	300 g/cm² or more	200 g/cm² or more	100 g/cm² or more
Moisture		22% or less	22% or less	22% or less
Crude protein		1.5% or less	2% or less	3% or less
Unmelting residue in boiling water		2% or less	3% or less	4% or less

(C) Square agar-agar

Grade / Item	No. 1	No. 2	No. 3
Color	1. White and lustrous or milk-white and somewhat lustrous. However, slightly yellowish or blackish agar-agar is allowed. 2. Colored agar-agar uniformly and finely colored.	1. White and milk-white agar-agar not remarkably tinged with yellow, red or black. 2. Colored agar-agar somewhat lacking in coloring uniformity.	1. Agar-agar tinged with light yellowish brown or reddish brown. 2. Colored agar-agar not greatly lacking uniformity.
Shape	1. Satisfactory in square form. 2. Free from deformed or broken ones.	1. Normal in square form. 2. Free from broken ones, but with those slightly deformed.	1. Somewhat inferior in square form. 2. With deformed once but within 4% of broken once mixed.

Uniformity	1. Satisfactory in uniformity both in color and shape. 2. Perfectly free from impurity. 3. Free from Shibi and Dankan.	1. Almost uniform in color and shape. 2. Containing slight impurity, Shibi or Dankan.	1. Lacking in uniformity in color or shape. 2. Containing Dankan or impurity.
Jelly strength	250 g/cm^2 or more	200 g/cm^2 or more	100 g/cm^2 or more
Moisture	22% or less	22% or less	22% or less
Crude protein	1.5% or less	2% or less	3% or less
Unmelting residue in boiling water	2% or less	3% or less	4% or less

Note : To pressed agar-agar, the column "Shape" shall not apply.

(D) Special agar-agar

Grade / Item	Superior	No. 1	No. 2	No. 3
Color	White and lustrous or milk-white and somewhat lustrous.	White and lustrous or milk-white and somewhat lustrous. However, remarkable yellowish or blackish agar-agar is allowed.	White and milk-white agar-agar, not remarkably tinged with yellow, red or black.	Agar-agar tinged with light yellowish brown or reddish brown.
Uniformity	Uniform in quality and size.	Uniform in quality and size.	Somewhat lacking in uniformity in quality and size.	Not greatly lacking in uniformity in quality and size.
Jelly strength	600 g/cm^2 or more	350 g/cm^2 or more	250 g/cm^2 or more	150 g/cm^2 or more
Moisture	22% or less	22% or less	22% or less	22% or less

Crude protein	0.5% or less	1.5% or less	2% or less	3% or less
Unmelting residue in boiling water	0.5% or less	2% or less	3% or less	4% or less
Crude ashes	4% or less	4% or less	4% or less	4% or less

(E) Scrap agar-agar

Grade / Item	Grade A	Grade B
Color	Normal	Somewhat inferior to normal
Jelly strength	100 g/cm² or more	100 g/cm² or more
Moisture	22% or less	22% or less
Unmelting residue in boiling water	4% or less	6% or less
Impurities	No impurities is tolerable.	Small percentage of impurities is tolerable.

Separate Paragraph :

Jelly strength Strength will be measured with the "Nikkansui" System Solidity Measuring Apparatus by using perfect 1.5% solution of agar-agar, after leaving it for 15 hours and coagulated at 20°C.

Moisture The specimen to be tested will be dried for 4 hours at a constant temperature of 100°C, and the decreased percentage in weight will be regarded as the amount of water.

Crude protein The amount of nitrogen will be determined through the Kjeldahl method, and the volume of nitrogen multiplied by 6.25 will be regarded as the amount of crude protein.

Unmelting residue in boiling water

The specimen to be tested will be completely dissolved

	in boiling water, and the weight of the insoluble substance expressed in percentage against the pre-dissolved weight of the specimen will be regarded as the amount of unmelting residue in boiling water.
Crude ashes	The specimen will be reduced to ashes, and their percentage against the original weight of the specimen will be regarded as the amount of crude ashes.

The standars for domestic agar by Ministry of Agriculture and Forestry are almost the same as the Export Standard described above.

The wide range of variation of all the characteristics in Japanese agar is sometimes pointed out. This is due primarily to the mixing of different species of seaweeds in different proportions and secondly to the great number of agar factories, each with its own modification of the production process. A slight variation in pH during cooking has considerable effect upon gel strength. If the pH is relatively more acid, gel strength will be low, but extraction will be rapid and more thorough. Some species of seaweeds are more affected by a low pH than others.

FISH-"FUSHI" (DRIED FISH STICKS)

I. "katsuo-fushi" (Dried Bonito Sticks)

1. Importance

Fish-"fushi" are a special product in Japan. They are prepared by boiling, broiling (smoking) and drying fish fillets. As raw materials for the fish-"fushi", bonito, albacore, big eye tuna, mackerel, and sardine are used. The fish-"fushi" are extensively used in preparing soups and broths. The fish-"fushi" are shaved with a sharp knife or blade and the thin flakes are added to hot water to make a soup base. Among them, that which is prepared from bonito has the best taste. The production of dried bonito-"fushi" began about 250 years ago. The amount of production of dried bonito-"fushi" was 8,580 tons in 1958 and 11,531 tons in 1968. The places of production are the entire coastline of the Pacific Ocean from Kyushu northward to Miyagi and Iwate Prefectures.

There are three principal methods of preparation according to the places of production : Satsuma-"fushi" (Kagoshima Prefecture), Tosa-"fushi" (Kochi Prefecture) and Izua-"fushi", or Yaizu-"fushi" (Shizuoka Prefecture). There are some differences in the processes of cutting, drying, fixing and mold growth, but the general methods of processing are almost the same. The bonito-"fushi" made in Shizuoka Prefecture are in demand in Tokyo district, and those which are made in Kochi Prefecture are liked in Osaka, Kyoto, Kobe districts.

2. **Effect of raw material on quality**

The quality of bonito-"fushi" depends upon the fat content of the raw bonito flesh. The "fushi" made from oily bonito meat (above 4～5 % fat-content) caught in Sanriku district in August are called "oily sticks", which are blackish brown, soft texture bitter taste and bad flavor. On the contrary, the "fushi" made from low oil content bonito (less than 0. 5 % fat-content) which are caught in the South Sea are red brown, poor taste and poor flavor. Therefore the raw materials should consist of raw bonito of moderate fat content (1～2 %). Bonito caught at sea from Okinawa to Shizuoka Prefecture contains a moderate amount of fat. The quality of the bonito-"fushi" also depends upon the freshness of the raw material. The fresher the raw material, the better quality of the finished product is produced. If unfresh raw bonito is used to prepare the dried sticks, their shape becomes elongated owing to the softened muscle. Such "fushi" are called "elongated fushi". The price of fish-"fushi" varies according to quality, size, and color of mold on the surface.

3. **Preparation of Bonito-"Fushi"**

The procedures for preparation of bonito-"fushi" as carried on in Shizuoka Prefecture are as follows : (a) Cutting of raw fish (heading, filleting and splitting), (b) placing the cut fish meat (strip) on a tray, (c) boiling, (d) cooling and removal of small bones, (e) first broiling (smoking), (f) pasting cracks, (g) second broiling (smoking), (h) first drying in the sun, (i) shaving, (j) second drying in open air, (k) allowed to develop mold several times. About three months are required to complete the processing.

a. Cutting raw bonito

The fresh bonito are beheaded, eviserated, and filleted. The two fillets of small bonito (less than 3 kg in weight) are called "kame-fushi". The two fillets of bonito larger than 3 kg are again cut lengthwise into four fillets ; the dorsal side fillets are called "o-fushi" (back meat "fushi"), and the ventral side fillets are called "me-fushi" (belly meat "fushi"). The back meat "fushi" is the most expensive.

b. Placing on a tray

The cut bonito meat (fillets) are placed on a tray for boiling. They must be placed in a position so that they remain straight.

c. Boiling

Eight to ten trays are placed in a round kettle, of which the diame-

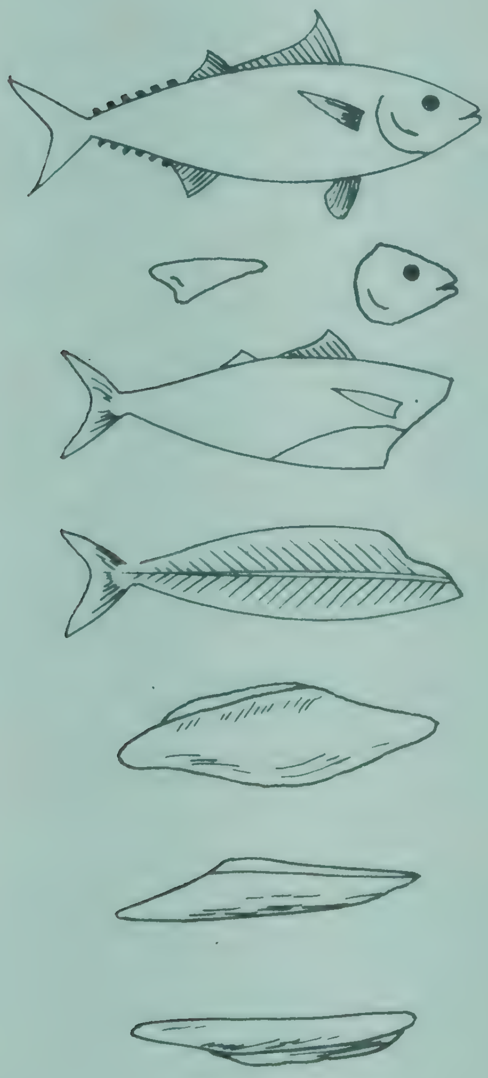

Fig. 5 - 15

Procedures of the preparation of dried bonito sticks.

A : Cutting of raw fish in the preparation of dried bouito sticks, heading filleting and splitting

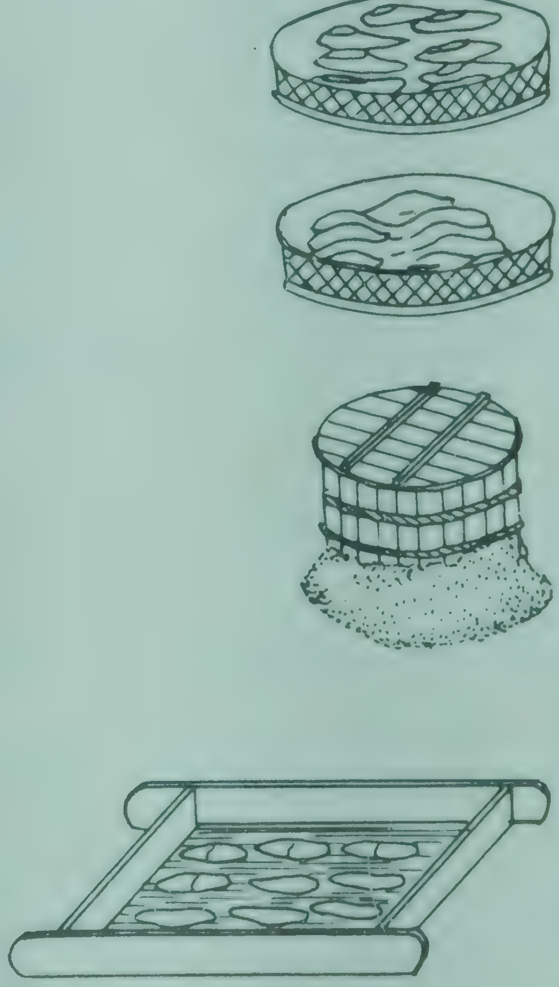

Fig. 5 - 16

B : Placing the cut fish meat on a tray and boiling in the preparation of dried bonito sticks.

ter is about 1 meter. The temperature in the kettle is 80°~85° C for fresh bonito meat, and 90°~95° C for unfresh bonito meat. The temperature is raised slowly, so as to prevent splitting, for about 20 minutes to boiling. The boiling is continued for 45~60 minutes for "kame-fushi", and for 60~90 minutes for "o-fushi" and "me-fushi". Oily strips are boiled for a longer time than the usual ones.

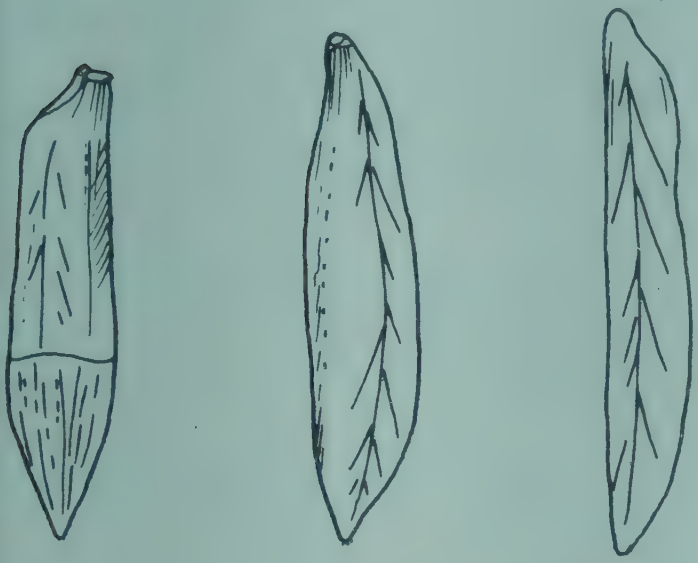

Fig. 5-17

C : "o-fushi" (back meat "fish")

d. Cooling and removing small bones:

After boiling, the trays are taken from the kettle and placed into a large tub filled with water, in order to cool. During the cooling, the surface of "kame-fushi" or "me-fushi" is two-thirds skinned and small bones are removed.

e. First broiling (smoking)

The skinned and boneless fillets, after boiling, are placed on wooden trays with open-work bottoms. Groups of 6~7 wooden trays are dried at first in the open air. When partially dried, the trays are placed in the broiling furnace (smoking furnace). These wood burning furnaces are constructed of stone or concrete and have an open top, above which 6~7 trays containing fillets, are piled so that the smoke passes up through the layers in the trays. The distance between the lowest tray and the fire is about 1.4 meters. Drying is continued until the dried surface becomes yellowish brown in color. The trays are roasted in order to achieve uniform drying.

f. Pasting

After the first broiling (smoking), cracks on the surface of the dried fillet are pasted with mashed waste meat of bonito which was boiled and broiled separately with the bonito fillets.

g. Second broiling (smoking)

The fixed fillets are placed back on the trays and dried on the trays and dried on the broiling furnace again. The temperature of the second broiling is high enough to cause the fillet surface to lose moisture. At night the trays are taken from the furnace and are piled so that the water-content in the fillet becomes uniform. The broiling (smoking) is repeated about ten times until the fillets have hardened. With the advance of the drying, the temperature of the furnace is lowered and the time of the broiling is shortened. The larger the number of broiling times, the better is the taste.

h. First drying in the open air

The broiled fillets are then dried as they are in the tray or on straw mats in the sunshine.

i. Shaving and Shaping

When the dried fillets are placed in a box for 3~4 days, the surface of the dried fillet become soft. The softened fillets are shaped by shaving the surface with knives having various shapes. After being shaved, the color of the surface of the dried fillets becomes brilliant red brown. The shaving operation requires skill.

j. Second drying in the open air

The shaved dried fillets are dried in the sunshine for two days turning the back and the ventral sides.

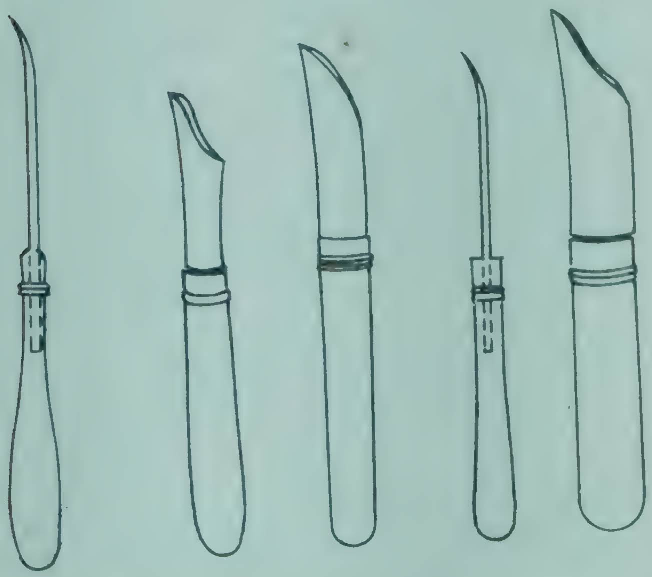

Fig. 5-18. Shaving knives

k. Mold

When the dried fillets are placed in a box for 13~14 days, molds (mainly *Penicillum* and *Aspergillus*) grow on the surface. This is called the first mold. The dried fillets having molds are taken from the box and are dried at first in the shade, and then in the sunshine. After the drying, the molds in thick layer or undesirable molds are removed from the surface with a brush, and then the fillets are placed in another box to allow molds to grow. This is called the second mold. The growing of mold is repeated four times. With an increase of the number of growing molds, the color of the surface of dried fillet changes from greyish green to light brown which is the characteristic

color of the dried bonito sticks. The purposes of the mold growth is to make a smooth surface, to adjust the moisture content, to decrease the apparent fat content, and to increase the good taste.
Some manufacturers employ the kind and growth of molds as an index of quality of the dried bonito sticks. The good species of molds grown on the surface of the dried bonito sticks are *Asp. glaucus, Pen. glaucum, Asp. melleus.* The undesirable species *Asp. flavo-viridescens, Torula sp., Cladosporium herbarum, Catennlaria fuliginea.*

4. **Yield of finished products in proportion to the weight of raw bonito**

The yield of the finished proportion to the weight of raw bonito is small, about 20 %. Therefore the product is expensive.

5. **Storage of bonito-"fushi"**

During the storage of the dried bonito sticks, insects are likely to penetrate into the dried meat, making holes. Manufacturers sometimes suffer considerable loss because of insect damage. In order to prevent such damage, the bonito-"fushi" are sometimes dried in the shade, or are stored in cold storage at 0° C. Sometimes they are fumigated with carbon disulfide. Insecticides cannot be used because they inhibit the surface mold growth.

II. Other Fish-"Fushi"

Tuna and mackerel have also been used to prepare dried fish-"fushi". However, tuna is not used at present, because it is more profitably used for canning. Mackerel are processed by the same procedures as those for the fish-"fushi". As mackerel are smaller than bonito, the fish bodies are filleted and broiled (smoked) 5～6 times, and mold is encouraged to form 1～3 times. Shaving is not carried on. At any rate the processing of the dried mackerel is simpler than that of the dried bonito. The amount of production was 13,955 tons in 1968.

Sardine are also used to prepare the fish-"fushi", but the processing is carried on even more simply than in the case of mackerel. Sardines are beheaded, eviscerated and filleted. The fillets are broiled (smoked) to dry. The dried sardine sticks are used by shaving to flakes for making soups or broths.

III. Partially-Dried Bonito-"Fushi" ("namari-fushi")

As in the preparation of bonito-"fushi", the bonito fillets are broiled (smoked) once on the furnace. The partially-dried bonito-"fushi" which are called "namari-fushi" are used as a daily food. This product can be prepared in a short time, hence volume of production is large, 8,942 tons in 1968.

SEASONED-DRIED FISH

As an item in the daily menu seasoned-dried fish has been processed in Japan from ancient times. This product is eaten after being broiled. The amount of production was 8,122 tons in 1962. The main places of production are Miyagi, Fukushima, Ibaragi, Chiba, Hyogo, Wakayama, Yamaguchi and Nagasaki Prefectures.

Fish are dressed and seasoned with a seasoning solution made from sugar, "shoyu" and sweet "sake" and are dried in the sun. This product is called "sakura-boshi" or "mirin-boshi", "suehiro-boshi", etc. according to place of producton.

Small fish are used for the preparation of this product : e. g. sardine small sea bream, small flat fish, pompanos (jack makerel), etc., of which the fat content is low. Small fish are split at the ventral side for removal of the visceral mass. Medium sized fish are filleted. The dressed fish are soaked in the seasoning solution for 1~2 hrs. The seasoning solution is made from "shoyu" (1. 8 liter), sugar, (45~560 g), sweet "sake" (360 cc) and sodium glutamate (3. 75 g). In order to give brilliance to the surface of the finished product a slight amount of agar, gelatine, wheat-gluten or glucose is added to the seasoning solution. The seasoned fish are dried in the sun.

SMOKED FISH AND SHELLFISH

I. Introduction

In the technology of fish and shellfish utilization, there are some products for which smoking is employed in their preparation : e. g. in the cases of dried bonito sticks, dried sea cucumber, dried scallop ligaments, and dried abalone as described above. But, the smoking employed in the preparation of these foods is not carried on for the purpose of importing a smoked odor, but its primary function to cause dehydration by boiling. As an example of this, the dried scallops or dried abalone are not liked for the quality of their smoked odor or for the blackish discoloration caused by smoking, accordingly the broiling is not carried on over a wood fire, but it is now done over a charcoal fire. The European method of smoking was imported for salmon in 1871～1872 in Japan, and it was studied for use with other kinds of fish during the succeeding 10 years on the basis of the imported method. As a result of these studies, such products were prepared, but they did not become popular for a long time afterwards. Only special products, such as smoked salmon or herring have been manufactured, and more recently they have become popular in Japan. The reason why the smoked foods have not been liked by Japanese, may be due to the fact that they did not seem to go well with rice, a main staple in the diet. After World War II, with the increase in bread eating more interest has been shown in smoked foods. During the war, besides the European smoking method, electric smoking and liquid smoking were studied and they have become popular.

The production of smoked fish and shellfish was 12, 255 tons in 1968 in Japan. Among them, the production of smoked squid meat, as well as smoked salmon, has increased recently. The smoked squid meat is prepared by boiling the squid (*Ommastrephes sloani pacificus*) meat, seasoning with sugar and sodium glutamate, and by smoking. The seasoned and smoked squid is used as a delicacy and is served with "sake" or beer.

II. Smoked Fish

In Japan, smoked salmon and herring are produced in small quantity as special products in Hokkaido. In 1968 the production of smoked salmon was 351 tons and that of smoked herring was 240 tons Those smoked fish are prepared after the manner carried on in Europe. The smoke houses are also of almost the same construction as the European, but on a smaller scale.

III. Seasoned-Smoked Squid or Octopus Meat

As a method of utilizing squid meat, besides the dried squid ("surume") the seasoned-smoked squid ("ika-kunsei") has been recently prepared abundantly in Japan, especially in Hakodate. Besides squid meat octopus or cod meat is also used for preparing such products. Those food items are preferably eaten by the Japanese as a delicacy with "sake" or beer. The processing of the seasoned-dried squid meat is as follows :

1. Dressing

Fresh squid (*Ommastrephes sloani pacificus* = *Todarodes pacificus*) or frozen squid are used. The cephalopodium and visceral mass are removed from the body of squid. At this time the tendons are also removed. The fin is cut off at the point of attachment. The removed parts are used for prepare fish-guano. The dressed bodies are thoroughly washed with fresh water.

2. Skinning

To accomplish skinning, the dressed bodies are soaked in hot water of 50°～55° C, being agitated to rub against each another. In the hot water the epidermis is dissolved by enzymatic action. It requires about 10～20 minutes of soaking to skin them completely. Unfresh squid require only about 10 minutes for skinning.

3. Boiling

The skinned squid are washed and boiled at 80°～90° C for 2～3 minutes.

4. First seasoning

The boiled squid are seasoned by sprinkling with seasoning materials. The proportion of the seasoning materials is as follows : for 3. 75 kg of boiled squid, salt 200～250 g, sugar 750～940 g, sodium glutamate 37 g and sodium 5'-ribonucleotide 3.7 g. The bodies sprinkled with the seasoning material are piled in two or three layers on a table, on which light pressure is applied under stones in order to cause the seasoning material to penetrate rapidly into the meat.

5. Smoking

The seasoned squid are hung from wooden bars in a smoke house. The smoking is carried on at 20°～25° C for the initial 1～2 hrs., at 50°～60° C for the succeeding period, and at 60°～70° C for the final 2～3 hrs. It requires about 7～9 hrs. to obtain good smoking.

6. Cutting

The smoked squid are cut into small rings of 1～2 mm width.

7. Second seasoning

The cut squid meat is seasoned by the second seasoning. At this time a seasoning solution comprised of 375 g of sugar, 100～110 g of salt, 3. 7 g of sodium glutamate, 0. 4 g sodium 5'-ribonucleotide and 500 cc of water is sprinkled upon the meat. The meat is then put in a stainless steel box and agitated in order to equalize the seasoning materials.

8. Drying

If the surface of the seasoned pieces of meat are wet, they are dried over a charcoal fire, or by infra red rays.

9. Packaging

Each 1, 870 g of the finished products are packaged in plastic film bags and sterilized in a steaming box at 85°～90° C for 30～60 minutes.

Seasoned-smoked octopus meat is prepared by the same procedures after the epidermis of the cephalopodium of the octopus are removed, and cut into small pieces (3 cm length). Seasoned-smoked cod meat is also prepared by the same procedures after the cod is filleted.

IV. Electric Smoking

In electric smoking the material is processed in smoke generated from burned wood sawdust and exposed to a corona discharge. Smoke so treated can adhere more easily to the surface of the product than it does when there is no such discharge. The electric smoking was invented by Toriyama [8]. In a smoke house a pair of electric wires are arranged, upon which wooden bars having electric wires for hanging fish are placed across the top. Fish are hung with iron wire from the wooden bars. Each two fish are used as electrodes. Electric wires are charged with direct current or indirect of high electric potential (10～20 thousand voltage) to cause a corona discharge. On the floor in the smoke house wood sawdust is burned as usual. The smoke rises being charged with positive or negative electricity by the corona discharge. The smoke charged with positive electricity flows toward the fish serving as electrode; on the other hand, the smoke charged with negative electricity moves toward the fish serving as the positive electrode. When direct current is used, the electric potential is raised with a neon-transformer. A schematic sketch of the apparatus using direct current is shown in Fig. 5-19.

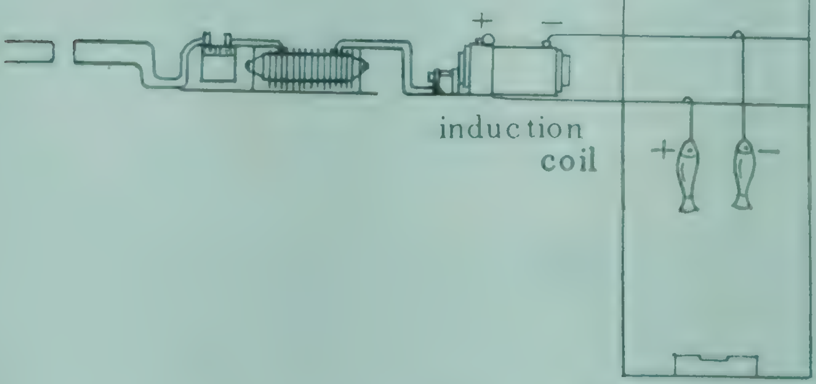

Fig. 5-19. A schematic sketch of electric smoking apparatus using direct current

The arrangement of the electric wires in a smoke house when indirect current is used is the same as in the case of using direct current. As electrodes, iron wire-netting can be employed for fish meat balls, or small fish. For continuous processing an endless wire conveyor belt is employed as shown in Fig. 5-20. Smoke is blown from one end of the smoke house.

The smoke charged with electricity readily adheres to the surface of fish body. With electric smoking the water in fish flesh is not dehydrated as rapidly as with ordinary smoking. Hence, the dehydration should be done by some other means : e. g. by drying in the shade. Salmon is processed in Otaru, Hokkaido by electric smoking.

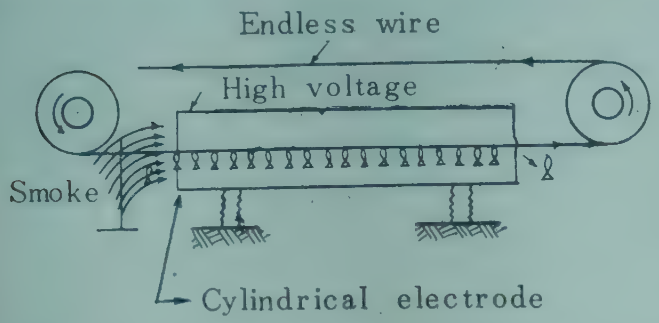

Fig. 5-20. Endless wire arranged for continuos processing in electric smoking

V. Liquid Smoking

As one of the quick-smoking methods, liquid smoking is carried on for fish or whale meat. A main component in the liquid is a wood vinegar obtained from the dry distillation of wood. For use in liquid smoking, wood vinegar obtained from the dry distillation is separated from wood tar by settling in a tank. The refined wood vinegar is diluted one third with water, and an adequate amount of salt is added. Into the diluted wood vinegar in a tank suitable quantities of fish are soaked for several hours. It is important to know the proper concentration of wood vinegar, temperature of the solution and soaking time. After having been taken from the tank, the fish are dried in the shade. Recently in Japan a synthesized smoking liquid has been made for preparing fish sausage or fish ham. This is made by mixing the various components obtained in smoke. There are several kinds of synthesized smoking liquor (water soluble or oil soluble) according to the kinds of foods : e. g. canned fish in oil, sausage, ham, whale meat "bacon".

Here, the processing of whale meat "bacon" with smoking liquid will be described ; it is an important article of merchandise. Whale meat "bacon" is perhaps not scientific word, but it is used in Japan for whale processed by liquid smoking. As raw material use is made of the blubber layer of the ventral side having wrinkles like ridges (this is called "une") and connective tissue-rich flesh (this is called "sunoko"), which is situated between the blubber and red flesh. When the carcass of the whale is cut, blocks (30~35×12~13 cm) are made by cutting the body at right angles with the skin. Those blocks are frozen or salted and are transported to the processing factory. The large blocks are cut into small blocks (30~35×4~5×12~13 cm) which have both blubber layer and connective tissue (this is called "une-su").

In the case of using frozen blocks, the thawed blocks soaked in a salt solution of Bé 3°, into which various spices and herbs with sugar are added, and furthermore potassium or sodium nitrite is added 0.2~0.3 % in proportion to the weight of blocks in order to redden the meat. In the case of using salted blocks, they are freshened with water, and are then boiled in a salt solution of Bé 3° at 75°~85° C for 4~6 hrs. When the boiling is completed, the block meat can be pierced with a chopstick. The boiled blocks are trimmed and then are soaked in a mixture of the synthesized smoking liquor (containing 10 % wood vinegar) and a dye (Scarlet S or Ponceau) for 1~5 minutes to let the dye penetrate to about 1 cm depth below the surface. After soaking, the blocks are air-dried for 20~40 minutes until the amount of water-content in the blocks reaches 45~46 %. After the drying, each blocks is packaged in a plastic film bag and processed at 100° C for 30 minutes. The yield of this product is 45~60 % of the original raw material.

DEVELOPMENT OF ARTIFICIAL DRYERS IN JAPAN

In sun-drying the curing proceeds so slowly in most cases, especially in bad weather, that a certain amount of decomposition is likely to occur before the desired reduction in water content is attained. The drying process is speeded up by controlled temperature, humidity and air velocity secured by means of mechanical dryers. Many attempts have been made during the past to prepare dried fish products by artificial drying and in a manner that would be economically feasible on a commercial scale.

At present, several forms of commercial dryers are employed in various parts of the world for the dehydration of foods : (1) Cabinet compartment dehydrators, (2) kiln dryers, (3) tunnel dehydrators, (4) rotary dryers, or (5) vacuum dryers.

In Japan, much progress in artificial drying has recently been made, and one finds many forms of equipment. In the dehydration of fish or shellfish, cabinet dryers or kiln dryers are mostly employed. The rotary dryers are employed for the preparation of fish meal. Rotary dryers, they will be described later in the chapter concerning the "fish meal industry". In connection with vacuum dehydrators, freeze-drying has also been studied in Japan, but it is not practical on a large scale.

I. Cabinet Dryers

As a sample of cabinet dryers, "Nansei's dryer" will be illustrated here ; it is one of the devices which are popular in Japan and is illustrated in Fig. 5-22.

The dryer has a large drying chamber with forced draft circulation ; it is provided with several holding trucks for conveying stacks of trays. Hot air is directed from a furnace through a duct into the drying chamber containing the material. The duct is specially designed. Circulation is across the trays. As dehydration proceeds the car is moved towards to the exit. This dryer is suitable for the processing of dried fish which uses the whole body. It requires about 2. 5 hours to dry fish or fish scraps.

II. Tunnel Dryers

This form of dryer is employed in many places in Japan for drying minced products such as fish scraps, or small fish. Heiwa's dryer is an example of this type of dryers. The arrangement of Heiwa's dryer is shown in Fig. 5-21.

The dryers are about 1 meter wide by 1. 36 meter high in cross section and 7. 3 meters long in a double line. Hot air is generated in a combustion furnace, and is passed into the long dryer. On the upper surface of the dryer many trays are piled side by side. Forced hot air passes through the piled trays. The furnace is designed so that the coal is burned clean.

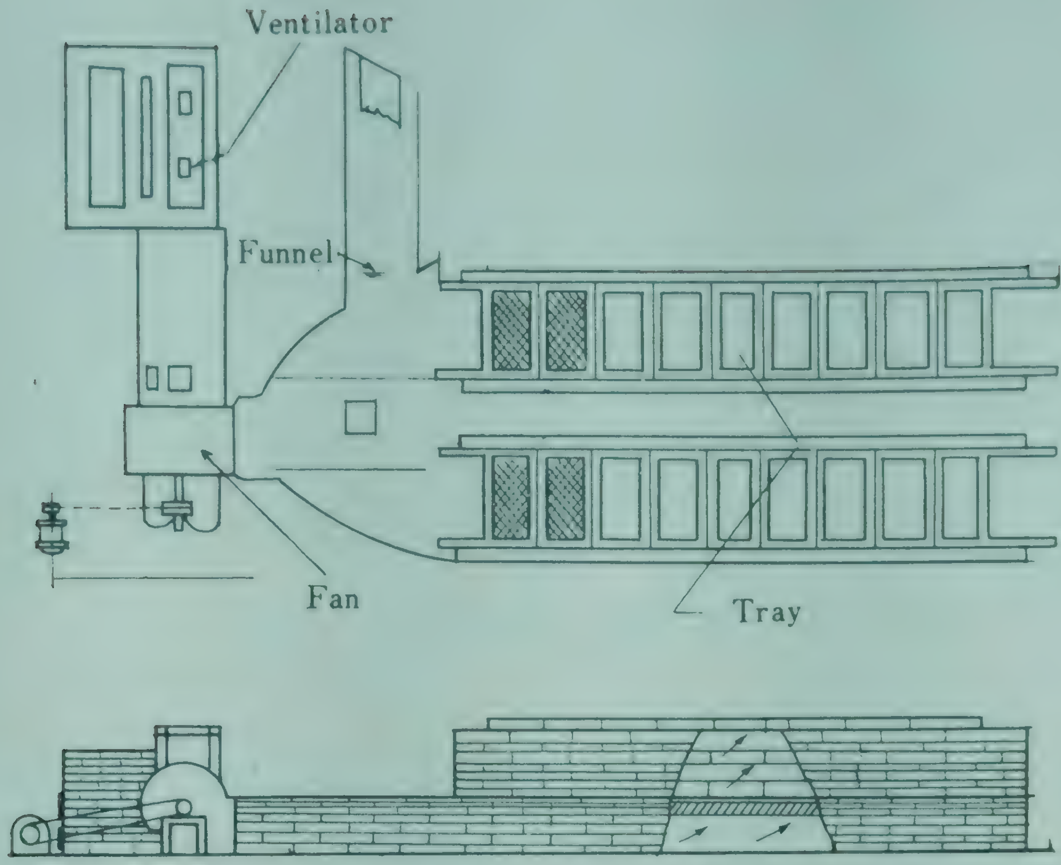

Fig. 5-21. Heiwa's dryer

III. Freeze-Drying

Natural air-dried fish or fish artificially dried in a dryer at atmospheric pressure has the objection that its character is so changed in the curing process that it absorbs water very slowly in soaking and upon reconstitution never attains the original gelationus character of the fresh fish. During storage further undesirable changes occur due to certain physical and chemical alterations in the flesh and oil of the fish. With respect to such problems much progress has been made and many problems have been solved. The correct temperature in relation to the denaturation of the protein has also been clarified. Here freeze-drying is being put into practice. In Europe and the U. S. A., some kinds of equipment are now in use. One of them is a "vacum contact plate dryer" devised by the Torry Research Station, Aberdeen, Scotland. In Japan freeze-drying has also been studied. Equipment is on the market. One type of equipment is Kyowa's freeze-dryer.

With such equipment, shrimp and whale meat have been dried. The capacity of Kyowa's RL-100 LV Type is as follows : Maximum dehydrating capacity —— 100 liters ; Condensation method —— refrigeration machine of two stage compressor using freon ; Size of tray is 500

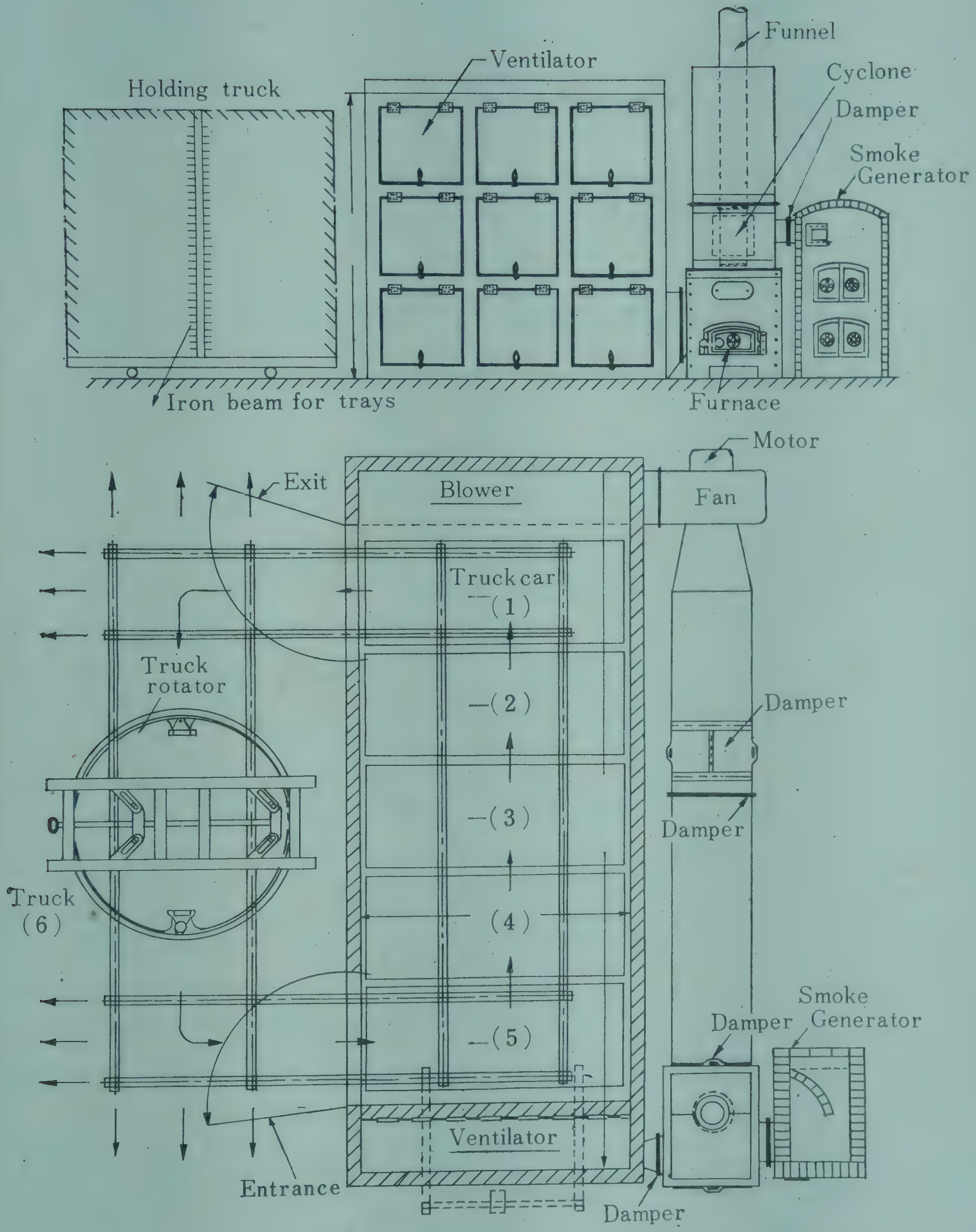

Fig. 5-21. Diagram of Nansei's dryer

×30 (mm), number of trays is 40 ; Size of drying chamber —— 1600 ×2100 (mm) ; Exhausting velocity and requirement of vacuum pump —— 300 liters minute, one pump requires the electric power of a 25 HP motor, for heater and others 10 KW are required ; Total height of the drying chamber is 3. 7 meter ; Floor space —— operating room 4×6 meters, machinery room 6×6 meter. The processing of freeze-dried fish and shellfish meat by use of such equipment is now under study and it is anticipated that such processing will be practiced before long in Japan.

CHEMICAL ADDITIVES TO THE DRIED MARINE PRODUCTS

Studies on the use of chemical additives for the purpose of improving the quality of marine food products have carried on in Japan. Such materials as coloring agents, flavors, non-nutritive sweetness, nutrients food fortification, preservatives, antioxidants, emulsifiers, and bleaches are all purposeful additives. Among those chemical additives allowed to use by legislation in Japan, some chemicals employed for the processing of the dried marine products will be discussed here.

I. Antioxidants for the Dried Marine Products

Antioxidants serve a useful purpose in retarding the development of oxidative rancidity in fats, or the oxidation of protein in fish meat.

1. Antioxidants whose used is permitted in Japan

The antioxidants which may be used in Japan are shown in Table 5-10.

Among those chemicals, BHA, BHT and IAG are the only ones whose use is permitted in dried marine products. In addition them ascorbic, citric, erysorbic acids and sodium erysorbate are employed not only as antioxidants, but also for the fortification of foods. The doses of the latter two are not restricted.

Table 5-10. Antioxidants whose used is permitted in Japan for marine products

Kinds	Foods	Concentration
BHA (butylated hydroxy anisole)	Fat and oil, butter, dried fish and shellfish and salted fish.	Up to 0. 2 g per 1 kg of the food iteself.
	Frozen fish and whale meat.	Up to 1 g per 1 kg of the solution in which the foods are soaked.
BHT (di-tertiary-butyl-paracresol or butylated hydroxy toluene)	Ditto	Ditto
IAG (iso-amyl gallate)	Salted fish and shellfish.	Up to 1 g per 1 kg.
	Frozen fish and whale meat.	Up to 1 g per 1 kg of the solution.
	Dried fish and shellfish.	Up to 0. 1 g per 1 kg.

2. Use of antioxidants

Because the oxidation of fat and oil advances after the lag period of the reaction, the antioxidants should be added to marine products before the lag period ; e. g. antioxidants should be added to the washing water employed during the initial preparation procedures, boiling water or soaking solution of NaCl, etc. Antioxidants are generally insoluble or only slightly soluble in water, so that they are at first dissolved in a appropriate solvent. The solutions may then be mixed with water to make an emulsion. Such mixed solutions are apt to be unhomogeneous in nature, so attempts have been made to secure homogeneous solution by mixing surface active agents with the antioxidants. When dry-salting is employed, the antioxidants are added to salt, or after the raw materials are soaked in antioxidant solutions, the materials should be dry-salted.

3. Effects of antioxidants

a. BHA (Butylated hydroxy anisole)

BHA is sold under the commercial name of "Sustane" ("Nippon-Kihatsuyu" Co.), "Tairyo-A" ("Ogawakoryo" Co.). This chemical is employed in the preparation of plain-dried fish, salted-dried fish, boiled-dried fish, seasoned-dried fish and fish-"fushi".

1) Plain-dried fish

The raw material is washed with fresh water containing BHA or is soaked in 0.01 % BHA solution and then air-dried as usual. Studies have shown its use in drying clam meat or in making dried "migaki-nishin" (dried herring fillets) to be effective.

2) Salted-boiled fish

During the salting, dry-salting or brining, BHA is added to salt or the salt solution. A concentration of 0.01 % of BHA is suitable. According to many studies, its use with salted-dried saury, flying fish, pompanos (jack mackerel), sardine and mackerel yielded good results.

3) Boiled-dried fish

BHA is added directly to boiling water, or an alcoholic solution of BHA is added to boiling water in a concentration of 0.01 %. The use of BHA for boiled-dried sardine, anchovy, sand lance is effective. If the boiling water is used repeatedly additional BHA should be added after each four or five boilings in the weight of 20% of the initial added amount.

4) Seasoned-dried fish ("sakura-boshi")

The dried product which is seasoned with "shoyu" and then dried —— seasoned-dried fish —— has a dark brown appearance, so that the oxidized color can not be distinguished, even if oxidation has definitely occurred. If BHA is added to the seasoning solution in the proportion of 0.01 %, oxidation is effectively prevented.

5) Fish-"fushi" (dried fish sticks)

In the preparation of fish-"fushi", boiling and broiling are employed. If oily raw bonito is used, the finished product has an oxidized color and it is advisable to use BHA in order to prevent or retard this condition.

b. BHT (Butylated hydroxy toluene)

This is sold under the commercial name of BHT (Nippon Kihatsuyu Co.) or "Tairyo"-T (Ogawa Koryo Co.). BHT is soluble in oil or alcohol, but not in water or propylene glycol. So use with oil is effective, but for dried fish it is less effective than BHA. A reason for using BHT is that its price is cheaper than that of BHA, and it can be employed in comparatively high concentrations. The method of use is the same as that of BHA. Generally BHT is employed in mixture with BHA.

c. IAG (Iso-amyl gallate)

IAG is sold under the commercial name of "Linton" (IAG 100 %) or "Linton" C (IAG 80 % and citric acid 20 %) (Yoshitomi Pharm. Co.). IAG is soluble in oil or alcohol, but only about 0.1 % soluble in water. The use of this chemical is effective in the preparation of dried marine product, but it has a defect in that it reacts with iron changing the color of the product to bluish violet. The method of use is the same as that of BHA. In brine-salting, IAG is employed by dissolving 0.1~0.05 % in the soaking solution. For the boiled-dried products, IAG is added to extent of 0.05~0.02 % of the boiling water. If a highly concentrated solution of IAG is employed, the color of fish body will be changed to bluish violet on contract with iron. It is wise to soak the fish or shellfish in the IAG solution just before drying.

d. Citric acid

This chemical is effective in preventing or retarding the oxidation of oil but it is not useful in the preparation of dried marine products.

e. Ascorbic acid

Ascorbic acid is used not only for food fortification, but also is employed as an antioxidant. If it is employed in mixture with BHA or BHT, the antioxidant effect will be increased. If ascorbic acid is employed alone as an antioxidant its effect is less than when used in combination with BHA or BHT. This chemical is employed only to prevent the discoloration of frozen fish.

II. Mold Inhibitor and Preservatives

Even if marine products are completely dried to less than about 40 % moisture content when stored in high humidity they reabsorb moisture from the air, and become perishable. During the dry-curing, if the weather is bad, the raw materials decompose and the freshness decreases. It is important that measures should be taken to prevent decomposition even in bad weather. At present light-salted products such as pompanos or saury, of which the moisture content is about 60%, are more in demand by consumers than the hard-salted-dried articles. The taste of such half dried foods having a small amount of salt is preferable, but they are perishable. In order to prevent spoilage, some preservative must be employed. More recently such dried foods are almost all packaged in plastic film bags for the retail trade. Unless these products have been completely dried, molds grow on their surface. Quite often molds grow on the surface of seasoned-dried squid or octopus which have a moisture content of about 50%. Therefore mold inhibitors or preservatives allowable for use with dried marine products in Japan are shown in Table 5-11.

Table 5-11. Preservatives permitted for dried fish and shellfish in Japan

Preservatives		Usage	Levels of use
	Sorbic acid Sodium sorbate Potassium sorbate	Seasoned-dried squid and octopus	Up to 1.5 g as sorbic acid in 1 kg of seasoned-dried squid and octopus

Sorbic acid is slightly soluble in water (0. 16 %), but quite soluble in alcohol (13.8 %). Sodium sorbate is soluble in water (25.6 %), but is slightly in alcohol (0.5 %). Potassium sorbate is soluble in water (67.6 %), but is slightly soluble in alcohol (0.5 %).

Sorbic acid exerts a marked inhibiting action towards mold and yeasts. Its action is more pronounced in an acid medium. When sorbic acid or its salts are employed for mold inhibition on seasoned-dried squid or octopus meat, they are added to the seasoning materials (sugar, sodium glutamate) and the mixture is used for the second seasoning in the processing (see p.277). If potassium sorbate is added to the seasoning solution in the proportion of 1/750 by weight, there is no growth of the mold on the seasoned-dried squid meat even after 35 ~ 50 days' storage. On the contrary, molds grow in 10 days on squid without such a potassium sorbate treatment.

III. Sodiumhypochlorite for Agar-agar

Among chlorine compounds, sodium hypochlorite is employed to prevent the putrefaction of agar gel during the processing of agar-agar. The bamboo blinds, on which the agar gel is placed, are sterilized with a solution of a concentration of 140～280 ppm for 30～60 minutes.

IV. Other Additives for Improving the Quality of Dried Fish or Shellfish

1. Polyphosphates

Several kinds of polyphosphates have an ability to hydrate protein. Takahashi(9)(10) has studied the hydration of sodium phosphate and some polyphosphates. He found that sodium phosphate (Na_2HPO_4) and a mixture of hexametaphosphate and tripolyphosphate effectively cause hydration. He has applied this property to enhance the ability of dried fish and shellfish meat to absorb water after drying. His method is as follows : When the dried squid ("surume") or dried herring fillet ("migaki-nishin") are prepared, after soaking raw squid meat in 5～10 % sodium phosphate (Na_2HPO_4) solution for 5 minutes or in a mixture solution (5 %) of hexametaphosphate and tripolyphosphate or tetrapolyphosphate (2 : 1) for 5 minutes, the treated squid meat is dried as usual. The dried squid meat treated with phosphates becomes able to reabsorb water even after storage. The polyphosphates are also effective in promoting penetration of the seasoning juice into the fish meat during the preparation of the seasoned-dried fish ("sakura-boshi" or "suehiro-boshi"). For this purpose, polyphosphate is added to the seasoning solution to the amount of 1～2 % by weight.

These compounds are also effective in retaining a soft texture in the finished products of the seasoned-dried fish for a long time, and to prevent the generation of white powder on the surface of the dried globefish which is seasoned with sweet "sake".

2. Surface active agents

If surface active agents whose use is permitted for foods as emulsifiers are employed by mixing with some preservatives for the preparation of dried squid ("surume"), they are effective in preventing the putrefaction of squid meat during the processing, even in bad weather. Tanikawa(2b) has demonstrated the prevention of dried squid meat ("ameika") by soaking squid in 1.0~2.0 % dehydroacetic acid solution for 5 minutes and then by spraying with span-20 (sorbitan monolaurate solution) to coat surface.

TECHNICAL PROBLEMS IN DRIED MARINE PRODUCTS

I. White Powder of Dried Marine Products

White powder sometimes yellowish or greyish, is seen often on the surface of the dried fish products. The white powder is usually produced during storing the product.

When the dried squid ("surume") is stored in the environment of a high humidity, a large quantity of white powder is produced, and is mentioned to be a mixture of betaine and taurine.(11) Tanikawa et al.(12) have studied the composition of the white powder by the paper chromatography. They found that the white powder is not to be made up of microorganism by microscopic and cultivating examination. The composition of the white powder is detected to be betaine, taurine, aspartic acid, glutaimic acid, histidine, and threonine. They further investigated the condition of the formation of the white powder at various humidities and temperatures.(13) The amount of the white powder formed on the surface of the dried squid on which the extracted matter solution had already exuded out, is larger according to higher humidity of environment, or lower temperature. When the dried squid after drying was sorted, no white powder is observed in the case of 90 % humidity of the environment, but white powder generated after 5 days in 70 % humidity and after 8 days in 80 % of humidity respectively. When the dried squid on which there is a small amount of white powder is stored, the amount of the flour become larger according to the higher humidity of the environment, or to the lower temperature. When the humidity of the environment is in excess of 90 %, the dried squid absorbs a larger amount of water and the quality of the dried goods become inferior. In order to make good quality dried squid which has a small amount of white powder, the dried squid after drying, must be stored in low humidity and at comparatively higher temperatures. When the dried squid is stored under 70 % humidity at 30°～37° C the formation of white powder can be prevented.

On the formation of white powder on seasoned dried cod ("fubuki-tara"), Tanikawa et al.(14) have studied its mechanism. The white powder on the seasoned dried cod is mold colonies which have grown on the crystals of sodium glutamate, sodium chloride and sodium succinate. When the product is left under high humidity at the initial storing period, then is stored under low humidity, sodium glutamate, sodium chloride and sodium succinate which are added to the product for seasoning, are crystallized with the growth of mold colonies.

II. The Effect of Various Preservatives on Keeping Freshness of Saury for Seasoned-Dried Product

Akiba et al.(15) have studied on the effect of furyl-framide and chlortetracycline with ice for preserving saury intended for processing as a seasoned dried product "mirin-boshi". The storing period is lengthened as a result of icing with these preservatives. The antibiotic effect is seen in the initial stage of the icing. For the pre-treatment of oily saury, butylated hydroxy anisol (BHA) is effective for preventing the oxidative deterioration of the body oil. The effect of BHA does not last until the time of processing the saury as a seasoned dried product "mirin-boshi".

III. Problems of Smoked Squid Product

Smoked squid products are mainly produced in Hakodate, Hokkaido. One of the problems in smoked squid is growth of mold during storing the products especially in summer season of high temperature and humidity of environment. Tanikawa et al.(16) have studied the preventive method for the growth of molds, and have found that sorbic acid and its sodium or potassium salts with propylene glycol are most effective. Two g of sorbic acid added to 1 kg of smoked squid product are available for prevention of mold growth in commercial use.(17) Gas packing is also effective to control mold growth. Complete destruction of the spores of molds on smoked squid is done by heating the packaged squid in nitrogen gas at 60° C for 5 minutes.

Seasoning for the preparing of smoked squid product yields waste which contains sugar, salt, water soluble proteins, extractives, and other ingradients. Motohiro(18) studied to recover pure sugar syrup for second utilization to the squid product. The water soluble proteins in the waste coagulate by adding phosphoric acid and calcium hydroxide. The proper concentrations of the acid and the alkaline are 0.03~0.04 % and 0.40 %, respectively. A filter can properly remove the coagulated proteins in the waste. Ion exchange resins such as Amberlite IR-20 and IRA-401 are effective to remove particular squid flavor and malodor in the waste. Sugar content of the syrup decrease by repeating the reproduction procedure. If the syrup of which sugar content lower than 10 % is used for seasoning, insufficient dehydration of the squid may result in to a poor quality of the product.

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FISH-SALTING INDUSTRY

I. Introduction

Before World War II, there was a large production of salted fish in Japan. More recently the amount of production has not expanded very much in comparison with the increased production of other types of marine products, e. g., canned foods, frozen foods, and fish sausage. The amount of salted fish produced from 1964 to 1968 is shown in Table 6-1.

Table 6-1. Production of salted fish (tons) (1964-1968)

Kinds	1964	1965	1966	1968
Sardine	2, 533	2, 443	2, 848	2, 335
Mackerel	32, 531	41, 989	53, 242	71, 831
Salmon				
Land factory	22, 528	23, 587	29, 580	28, 940
Floating factory	1, 378	1, 421	1, 416	1, 443
Total	(23, 906)	(25, 008)	(30, 996)	(30, 383)
"Masu"				
Land factory	17, 171	28, 311	22, 368	25, 336
Floating factory	110	327	153	177
Total	(17, 281)	(28, 638)	(22, 521)	(25, 513)
Cod and Alaska pollack	14, 230	16, 437	11, 551	12, 837
Roe of cod and Alaska pollack	9, 979	11, 611	14, 336	24, 700
Herring	199	822	1, 945	2, 491
Herring roe	508	641	1, 089	2, 059
Atka mackerel	5, 960	6, 927	7, 523	2, 138
Saury	5, 491	3, 269	7, 146	1, 191
Squid	475	1, 084	1, 074	623
Whale meat	13, 409	12, 225	10, 070	5, 826
Other	3,119	2, 847	2, 933	2, 069
Total	129, 628	153, 947	167, 280	184, 005

As seen in Table 6-1, the production of salted fish from 1964 to 1968 averaged about one hundred fifty thousand tons including that prepared by the floating factories. The consumption of salted fish has decreased recently in the cities, and the amount of raw fish available for salting has not increased, because the demand for frozen foods or processed goods (smoked, canned goods or fish sausage) has increased. As to the kinds of raw fish, Atka mackerel, saury, squid and whale meat have decreased while mackerel, roes of cod and Alaska pollack, herring, and herring roe have increased. The increase of salted mackerel is perhaps due to the increase of the catch, and that of herring and herring roe due to increase of imported raw herring. The decrease of availability of those fishes is due principally to the decrease of the catch. At any rate, the amount of production of salted fish is not expected to increase remarkably in future. In Japan from ancient times roe has been a favorite food, so if there is an increase in the catching of fish, of which the roe is suitable for salting, the amount of the production will probably

Table 6-2. Principal place of production of salted fish and fish roe (Prefecture)

Sardine	Mackerel	Salmon roe	Cod and Alaska pollack and their roe
Iwate Ibaragi Toyama Hyogo Tottori Yamaguchi	Iwate Ibaragi Chiba Shizuoka Kyoto Hyogo Tottori Yamaguchi Fukuoka	Hokkaido Floating factories	Hokkaido

Herring and its roe	Atka mackerel	Saury	Squid	Whale meat	Others
Hokkaido	Hokkaido	Hokkaido Iwate Miyagi Wakayama	Hokkaido	Hokkaido Iwate Miyagi Floating factories	Hokkaido Miyagi

increase.

The principal places of production of salted fish and fish roe are listed in Table 6-2.

Salted fish is not only used as an every day dish, after broiling, but it is also employed in the processing other merchandise, e. g., smoked fish or seasoned goods. Among the many kinds of salted fish or fish roe, special products in Japan are the salted roes of salmon, cod and Alaska pollack. Almost all of the salted fish roe is produced for domestic consumption.

In Japan almost all of the salted fish are dry-salted except brine-salted salmon for subsequent later smoking. The dry-salting method itself is almost the same as that of used in Europe and America except for the container or tank and the handling or preparing of the fish. In preparing fish, in Japan from ancient times the head is left untouched; the large size fish are split on the ventral side, and the gills and internal organs removed.

II. Principal Kinds of Salted Fish and Fish Roe

The principal kinds of salted fish and fish roe manufactured on a commercial scale are as follows:

1. Herring : hard-salted, slack-salted.
2. Sardines : 〃
3. Mackerel : 〃
4. Saury : hard-salted, slack-salted.
5. Cod or Alaska pollack : salted split cod or Alaska pollack, slack-salted cod or Alaska pollack.
6. Atka mackerel : hard-salted, slack-salted.
7. Salmon : hard-salted, slack-salted.
8. Whale meat : hard-salted.

The salted products listed above (No's 1～8) must be inspected under the "Regulations" of the Japanese Government (Quality Standard and Inspection Procedure by Ministry of Agriculture and Forestry) before they can be put on the market.

9. Light salted herring : packed in a wooden box.

10. Cod stomack : slack-salted.
11. Yellow tail : 〃
12. Flat fish : hard-salted, slack-salted.
13. Shark meat : hard-salted.
14. (Wachna cod, "komai" *Eleginus navaga*) : hard-salted, slack-salted.
15. Fish roe : herring roe ("shio-kazunoko"), salmon roe (whole style : "sujiko", separated roes : "ikura") : hard-salted, slack-salted.

The salted products listed above (No's 9～15) are inspected under a law of Hokkaido Prefecture. In addition to the salted products, jelly fish and anchovy are salted to some extent in Japan.

III. Regulations regarding Inspection of Salted Marine Products in Japan

Salted products which are manufactured in several Prefectures are inspected under the Regulations of the Ministry of Agriculture and Forestry, and those manufactured in only one prefecture are inspected under Regulations of the respective Prefecture. In the Regulations of the Ministry of Agriculture and Forestry, salted herring, sardine, mackerel, saury, cod, Alaska pollack, Atka mackerel, salmon and whale meat are defined and classified into three grades respectively as described below.

1. Ministry and Prefecture-defined kinds of salted fish

a. Salted herring

Salted herring is classified into two categories : hard-salted and slack-salted. The former is round herring to which is added salt to above 25% by weight of the whole raw fish followed by curing over 20 days. After the curing period, the fish are drained and additional salt to the extent of over 5% by weight of the drained fish is added. In slack-salting, approximately 15% by weight of the raw fish is added to the round herring and they are cured for 3 days or longer. After the curing period the fish are drained, and 5% additional salt is added to them.

b. Salted sardine

Salted sardine are defined as round sardines to which is added about 15% of salt by weight of the whole fish from April to October (from November to March above 10%), and which are cured more than 24 hours. After storage the fish are drained and 5% additional salt is added.

c. Salted mackerel

Mackerel are gutted and eviscerated (mackerel of which the length is less than 18 cm may be salted without gutting and eviscerating). About 15 % salt is added to the prepared fish from April to October (from November to March above 10 %), and they are cured for one day or longer. After the curing, the fish are drained and 5 % additional salt is added.

d. Salted saury

Salted saury is classified into two categories : hard-salted and slack-salted saury. The former is saury to which is added about 25 % by weight of salt followed by curing for 7 days or longer. The cured fish are drained and 5 % additional salt is added. Slack-salted saury is round saury with about 15 % by weight of salt added from April to October (above 10 % from November to March), after which it is cured over 24 hours. After the curing, the fish are drained and 5 % additional salt is added.

e. Salted cod and Alaska pollack

Salted cod and Alaska pollack are classified into two categories respectively : salted split cod or Alaska pollack and salted dressed cod or Alaska pollack.

The salted split cod or Alaska pollack are manufactured as follows : cod or Alaska pollack is split at the back or belly side. If they are prepared without removal of head, they are gutted and eviscerated. If they are prepared without the head, they are first beheaded and eviscerated, and the part of the back bone until the third dorsal fin is removed by cutting. About 20 % salt is added to the prepared fish and they are cured for 5 days or longer. The salted dressed cod or Alaska pollack are manufactured as follows : if they are prepared with head, they are gutted and eviscerated. If they are prepared without head, they are at first beheaded and eviscerated, without removing any back bone. To the prepared fish is added about 15 % of salt and they are cured for one day or longer.

f. Salted Atka mackerel

Salted Atka mackerel is classified into two categories: hard-salted Atka mackerel and slack-salted. For the hard-salted Atka mackerel the fish are beheaded and eviscerated (if the fish is less than 27 cm long, the need not be beheaded and eviscerated). To the prepared fish is added about 25 % of salt and it is cured for 10 days or longer. The slack-salted Atka mackerel is prepared with head or without it.
If prepared with head, the fish are gutted and eviscerated. If they are prepared without head, the fish are beheaded and eviscerated (if the fish is less than 27 cm long, head and viscera need not be removed). To the prepared fish is added about 15 % of salt and they are cured for 2 days or longer.

g. Salted salmon

Salted salmon are prepared from pink or chum salmon. They are also classified into two categories: hard-salted salmon and slack-salted. For the former the salmon are gutted and eviscerated. To the prepared fish is added about 25 % of salt and they are cured for 10 days or longer. After the curing, the fish are drained and 5 % additional salt is added. The latter means that the salmon are gutted and eviscerated and they are salted with salt of about 10 %.

h. Salted whale meat or blubber

Salted whale meat or blubber means blocks of whale meat or blubber to which 30 % of salt is added followed by curing for 20 days or longer. The cured blocks are drained, and 3 % salt is added.

i. Light salted herring

Light salted herring is herring cured with less than 15 % salt.

j. Salted cod stomach

The stomachs of cod with the gullet connected are salted with about 20 % by weight of salt.

k. Salted yellow tail ("buri")

The yellow tail is gutted and eviscerated and cured with about 20 % salt. Sometimes the split or fillet of this fish with the back bone removed is salted.

l. Salted flat fish

Salted flat fish is classified into two categories: hard-salted and slack-salted. For the former the fish are eviscerated and cured with about 20 % salt for 3 days or longer. After curing, the fish are drained and 5 % salt is added. For the latter the fish are eviscerated and about 15 % salt is added. If the fish are less than 15 cm long they need not be eviscerated.

m. Salted shark

"Salted shark" means cut shark meat cured with about 20 % salt for 3 days or longer. After curing the cut fish are drained and 5 % salt is added.

n. Salted Wachna cod ("komai")

Salted Wachna cod is classified into two categories: hard-salted and slack-salted. For the former the fish are beheaded and eviscerated and cured with about 20 % salt for 3 days or longer. After the curing 5 % salt is added. For the latter the fish are beheaded and eviscerated and cured with about 15 % salt. Salted Wachna cod also include the salted split fish.

o. Salted fish roe

Salted herring roe is called salted-"kazunoko". It is classified into two categories: hard-salted and slack-salted. The former means the fish roe is cured with 20 % salt and in the latter the salt concentration is about 10 %. There are two kinds of salted salmon roe: salted salmon roe (whole style: "sujiko") and salted separated roe ("ikura"). Salted cod roe or Alaska pollack roe are called salted "momijiko".

2. Governmental Inspection Regulation for salted fish and fish roe

The salted fish inspected under Japanese Governmental Law are classified into three grades. Inspection includes consideration of the following factors: fleshiness, color, taste, shape, freshness, moisture-content, amount of salt added and degree of penetration and the absence of foreign matter.

As an example, the grades of salted salmon are shown in Table 6-3.

Table 6-3. Grades of salted salmon inspected under Governmental Regulations

Inspection factors	First grade	Second grade	Third grade
Shape	1. Well-shaped 2. No external injury 3. No loss of scales, which are fixed	1. Fairly well 2. Small injury as marks 3. Slight loss of scales	1. Poor shaped 2. External injury is large 3. Large number of lost scales
Fleshiness	1. Firm and elastic fleshiness 2. No loss of fleshiness	1. Fairly firm fleshiness 2. Small amount of deformed fleshiness	1. Fleshiness is not firm 2. Large quantity of deformed fleshiness
Oxidation	There is no oxidation of fat	Slightly oxidation	Marked oxidation
Color	1. The back is silver blue, belly side is silver white. Negligible that there are light red spot on the surface of fish body. 2. The color of meat is reddish orange. 3. No abnormal color.	1. There are some spots on the surface of fish body. 2. The meat is brilliant yellowish white. 3. Slight abnormal color.	1. The surface of the fish is dark violet. 2. The color of the meat decolored. 3. Considerable abnormal color.
Taste	Characteristic flavor	1. Slight loss of flavor 2. Slight oxidized fat odor 3. Slight bitter, but no stimulative or putrefactive odor.	1. Inferior flavor 2. Much oxidized fat odor 3. Bitter, but no stimulative or putrefactive odor.
※Amount of	Hard-salted	Ditto	Ditto

salt penetration into the meat	is above 12 %		
Presence of foreign matter	Absence of sand or foreign matter	Ditto	Ditto

※ The estimation of the amount of salt penetrated is carried by the titration with 2.9 % $AgNo_3$ solution.

IV. Salting Procedure

1. Salmon

Salted salmon has two customary uses: one is for daily dishes, and the other is as a raw material for smoked salmon. The former is dry-salted such as hard-salted salmon ("shiobiki-sake") or slack-salted salmon ("aramaki-sake"). The latter is also dry-salted, but sometimes it is brine-salted according to Russian style, or is mild cured as American style. In Japan, for dry-salting, chum salmon or pink salmon are used. Prior to being smoked, red salmon is preserved and cured by brine-salting. In the past, the Japanese have liked hard-salted salmon ("shiobiki sake". However, recently with the change of eating customs the production of hard-salted salmon has decreased while that of slack-salted has gradually increased. Among fish of *Onchorhynchus* which are caught in the northern Pacific Ocean, chum salmon is slack-salted, some pink salmon is hard-salted in addition that used for canning; most of the red salmon is canned, but some salted for use in preparing smoked salmon; silver salmon or king salmon are also mainly processed for canning while a limited amount is mild-cured.

a) Hard-salted salmon ("shiobiki-sake")

Pink salmon or chum salmon caught in the northern Pacific Ocean or near Hokkaido is hard-salted in land factories or floating factories at sea. The fish split along the belly side after gutting, and then the visceral mass is removed. The kidney is removed with a brush after cutting with a knife. This is followed by a thorough cleaning and scrubbing in fresh clean water. After proper draining the fish are laid in piles to the height of one meter on straw mats on the floor or deck. A thin sprinkling of salt is first scattered over the straw mat. Layer by layer the fish are laid down, placing each layer as nearly as possible. Salt is then spread evenly over the fish in amount approximating 30 ~ 40 % by weight of the fish. The heap of fish is then covered with straw mats. After 10 days of curing and when the fish becomes slack, the cured fish are transported in holds to the home ports, where the fishes are packed in wooden boxes. In the land factories, the drained fish bodies are salted as they are laid in wooden boxes. In one box, sixty pink salmon or 28 chum salmon are placed. Because this article of marchandi is prepared as a side-line in the most busy fishing season when canning is mainly carried on, good quality is not desired, so the price is cheap. The fat in the salted fish meat oxidizes to become yellow brown on the surface.

Recently the method has been improved; the stack of salted fish are packed in wooden boxes after the salt has penetrated into meat. After removal from the pile the salt adhering to the fish bodies is removed by striking two fish as they are held in the hands; then the fish are washed and scrubbed in a weak brine to remove any accumulated salt, slime and blood. Next they are packed in wooden boxes. A handful of salt is placed on the bottom of each box, with a sprinkling between each two layers. The contents of a box weights 48. 6 kg (the number of fish bodies is 60 for pink salmon and 28 chum salmon). The amount of salt used for packing is 7. 5 kg.

b) Slack-salted salmon ("aramaki-sake")

Recently the production of slack-salted salmon has increased. Because of the demand the price has become higher than that of hard-salted salmon. This commodity is prepared mainly from chum salmon. The amount of salt used is about 20 % of the weight of the raw fish. This slack-salted salmon can not be preserved for a long time at room temperature, therefore it must be kept in cold storage until sold.

Raw chum salmon to be prepared for slack-salting are washed, beheaded in the usual manner, gutted and split along belly side. The visceral mass is removed. This is followed by a thorough cleaning and scrubbing in fresh clean water. After proper draining the fish are salted in the belly cavity from which visceral mass has been removed. Finally the fish are packed in a wooden box (90×45×18 cm). A thin sprinkling of salt is scattered over the bottom. A layer of fish is then placed with the back side aslant. Salt is next scattered evenly over the surface of the layer, and then the last layer should be slightly overfilled above the sides of the box. The ratio of the amount of salt which is put in the gill cavity and belly cavity to that which is scattered in the space between the layers of fish is 3 : 7. The packed boxes are piled five boxes high on the floor in the land factories or on the deck in floating factories. On the top of the upper layer of boxes, is placed a stone of about 38 kg weight. After several hours, when the over-filled fish has been compressed below the level of the side of the box, covers are nailed on the boxes and they are placed in cold storage.

2. **Herring**

In the past, herring has been consumed as raw fish as a daily dish or largely prepared as dried herring ("migaki") or fish scrap. However, with the decrease of the catch, herring is not now used for fish scrap, but is prepared as a salted or dried product. However, the salting of herring in Japan is an industry of minor importance. In the salting of herring, the round herring is prepared as slack-salted or hard-salted fish. For the former salt to 10 ~ 20 % by the weight of the raw fish is added according to the season; this is called "hitoshio-nishin". The latter is cured with more than 30 % of salt.

a) Slack-salted herring

The fresh herring are washed to remove loose scales, blood, and slime. Then without beheading or further cleaning salt is scattered over the fish on a concrete floor or straw mat on the concrete floor using 10~20 % of salt to the weight of the raw fish. The salted fish are packed in flat wooden boxes and transported by freight-car to market. In April to May (10°~15°C) the slack-salted herring (with 10 % salt) can be preserved for 7 ~ 8 days, that with 15 % salt for 10 days, and that with 20 % salt for 17 ~ 20 days.

b) Hard-salted herring

Hard-salted herring are prepared with round herring in the same manner as in Europe or the United States of America.

3. Sardines and Saury

Sardines or saury are dry-salted with salt to 20 % of the weight of raw fish. In Japan there is also a salted and dressed sardine which is processed according to western style. Sardines are brined in flat shallow barrels placing the fish bodies in a radial direction with the tails to the center of the container. The water which escapes from the fish bodies is drained through a small hole at the bottom.

4. Mackerel

Mackerel caught during the autumn and winter are dry-salted. The procedures are carried out according to occidental style.

5. Anchovy

Anchovy is salted in occidental style.

6. Atka mackerel

With the decrease of the catch of herring, the Atka mackerel has come to be salted in large quantity. Atka mackerel is more perishable than other fish, so it must be cured as promptly as possible after being caught. The fish are gutted and split at the belly side without beheading, and the visceral mass is carefully removed. The fish are then soaked in fresh water or dilute salt solution for one hour in order to remove the blood. The fish are then washed thoroughly and the kidney is removed with a knife. After another thorough washing the fish are drained on a bamboo blind. Salting is carried out first by dry-salting with salt at 20 % of the weight of the fish from spring to autumn, and with 15 % from autumn to winter. A thin sprinkling of salt is scattered over the bottom of barrel. The fish which are rubbed with salt inside of the belly cavity and on the head are laid in the barrels as close together as possible. In addition some of the salt is scattered over each layer. Then the next layer is placed crosswise to the first layer, with a light sprinkling of salt. This "preliminary curing" stage is continued for 10 to 14 days. During this period the barrel is pressed by a stone weight, and kept in a cool place. After draining, the preliminarily cured fish transferred to a separate barrel as for the "regular cure". The salt for the regular curing is 15 % from spring to summer and 10 % from autumn to winter.

7. Cod and Alaska pollack

Cod and Alaska pollack salting is not a very important industry in Japan. The salting of cod was one of the earliest salt-fish industries in Hokkaido, but it has not increased. The cause may be that the amount of the catch has decreased plus the fact that the Japanese like raw cod meat better than the salted cod. Therefore the slack-salted cod ("shintara") is preferred to hard-salted. Cod is manufactured as salt-dried rather than as salted fish. Hard-salted cod is manufactured according to American style. Slack-salted cod is manufactured in Hokkaido as follows: fresh fish is beheaded, eviscerated without splitting the belly side and put it into a water tank to remove blood and other extraneous material. After draining, salt is added to the belly cavity and is rubbed on the surface of the fish. The salted cod is packed in a box. The amount of salt added is 12 ~ 13 % by weight of fish from October to November, 7 ~ 8 % from December to February, and 15 % from March to April.

8. Yellow tail ("buri") (*Seriola quinqueradiata*)

Salted yellow tail is liked by people in western Japan. It is said that the product in Fukui and Ishikawa Prefectures is the best. Therefore, it is a product for domestic consumption. The preparation of salted yellow tail is carried out as follows: fresh yellow tail is gutted and split at the belly side from the operculum to anus with a knife, and the visceral mass is removed. At both lateral sides, lines of notches are made with a knife from head to tail. The preparated fish are washed thoroughly with fresh water and then with dilute salt solution to remove the blood. After draining salt is rubbed in the belly cavity, mouth, the notches and all over the surface of the fish. The amount of salt is 2~2.8 kg for one fish. The salted fish are piled on straw matting on the floor, covered with straw mats and stored for about 10 days. During this time the layers of fish are rotated from top to bottom.

9. Whale meat

In Japan whale meat and blubber have been salted from ancient times. The best product is salted whale tail meat. This is called "oba". The whale tail meat is cut in blocks (36 × 18 × 3 cm) and soaked in cold water to remove the blood. After draining, the blocks are salted in a barrel. Stone weights are placed on the cover plate to press out surplus brine in which the meat is soaked. Blubber and belly meat ("unesu") are also salted like tail meat. Whale red meat is rarely salted, but is refrigerated. For the salting of red meat, blocks of it are soaked in cold water with several changes to remove the blood. After draining the blocks are salted with 20 % of salt.

10. Jelly fish ("kurage")

Of the jelly fish, "bizen-kurage" (*Rhopilema esculenta*) is eaten. For its preparation, the jelly fish is soaked in cold water for 8 ～ 10 hrs. to remove mucous substances. After draining, the surface of the jelly fish is rubbed with a mixture of salt (about 14 kg) and alum (75 g) about 20 % by weight and is cured in a barrel for 2 ～ 3 days. As the salt extracts the water from the jelly fish, the weight decreases. After the curing, the bodies are again washed and drained. To the drained fish is added a mixture of salt and alum (the weight is 80 % of the original mixture added), and they are packed in barrels.

11. Fish roe

From the visceral mass removed from the fish, the roe are salted and they are well liked by Japanese. Of the salted fish roe, that of salmon, cod, Alaska pollack and herring are most widely produced.

a) Salmon roe

When a whole ovary is salted, it is called "sujiko", and when roe grains separated from the ovaries are salted, the product is called "ikura" (a Russian name).

1. "Sujiko"

It is important to use fresh ovaries to prepare a good quality finished product. After removal from the salmon the ovaries are washed in a bamboo basket in water in order to remove blood, mucous substances etc. The washed ovaries are drained on a bamboo blind. The drained ovaries are salted according to either of two methods: dry-salting or brining.

i) Dry-salting ("tana-zuke"-method)

In a wooden framework enveloped with straw matting the fish roe (ovaries) are salted with about 12% dry salt. The salt is spread over each layer. After one week of curing, the ovaries are turned over and sprinkled with 3% salt.

ii) Brining ("hako-kiri"-method)

Into a brine (saturated NaCl solution) tank, salmon ovaries are soaked with frequent stirring in order to make the salt penetrate uniformly. After being taken out from the tank, the ovaries are packed in a box and sprinkled 3% by weight of the raw ovaries with dry salt.

In the past, salmon ovaries were dry-salted only, but recently brining has been carried on in order to obtain more uniform penetration. After salting the fish roe are spread to a depth of 9 cm on a bamboo blind in order to drain; they are then covered with cotton cloth moistened with a saturated salt solution. After draining for 0.1 ~ 1 hr., the salted salmon roe are packed in boxes.

2. "Ikura"

"Ikura" is the mass of separated egg grains from the salmon ovary after they have been cured in salt solution. This is a slack-salted product, so it can not be preserved for a long time at room temperature. It must be kept in cold storage.

"Ikura" is prepared from the ovaries of chum or pink salmon. The eggs of the former are larger than those of the latter. The raw salmon should be fresh within 6 hrs. after being caught, because the quality of this product is significantly influenced by the freshness of the raw material. After removal from the raw salmon the ovaries are washed thoroughly in fresh water in a tank in order to remove the blood-vessels and extraneous material. The washed ovaries are rubbed through a gauze cotton net to separate the egg grains from the ovary membrane.

The egg-separating apparatus consists of gauze cotton net, a sloping gauze wire net and a receiver, of which the bottom is a gauze wire net. The separated egg grains run down the slope and drop into the receiver.

When the amount of separated egg grains have accumulated to an appropriate weight (58 ~ 75 kg) in the receiver, they are put into saturated NaCl solution (Bé 25°) prepared as follows. A previously boiled and cooled saturated NaCl solution is put in a tub (dia. 1 meter, depth 70 cm) to a volume of 270 liters. The percent of salt to the weight of the drained egg grains is added to the saturated NaCl solution. The soaked egg grains are stirred for 17 ~ 19 minutes. After soaking the egg grains are removed from the tub and placed in bamboo baskets, when they are drained for 2 ~ 4 hrs. The drained eggs are packed in a barrel or a wooden box. This product should be cold stored.

b) Cod or Alaska pollack roe

Cod (*Gadus macrocephalus*) or Alaska pollack (*Theragra chalcogramma*) roes are also cured. These are called "momijiko". After removal from the fish the ovaries are washed carefully in fresh water without breaking the membrane, use being made of a bamboo basket (60 × 45 × 30 cm). After washing, the ovaries are cured with good quality salt of about 15 % of the weight of the ovaries in a round tank (dia. 1.5 meters, depth 45 cm). A thin sprinkling of salt is scattered evenly on each layer, and the next layer of ovaries is laid down. When the tank is filled, the top layer is covered with a straw mat, and material is stored for 20 hrs. When the salt has penetrated into the ovaries, they are washed free of excess water and are drained on a bamboo blind. The drained ovaries are packed into small barrels after being shaped. Sometimes the salted ovaries are dyed with an edible red dye.

c) Herring roe

Cured herring ovaries are known as salted-"kazunoko". The ovaries are soaked in dilute salt solution for 2 ~ 3 days changing the solution once a day in order to increase their firmness. When the ovaries have hardened the membrane is torn away, removing blood-vessels and other materials. The stripped ovaries are soaked in fresh water for 2 ~ 3 days to bleach. The bleached ovaries are drained on a bamboo blind. The drained ovaries are cured in a small barrel with 10 % of salt by weight of the drained ovaries for slack-salting, or 20 % of hard-salting. The layer of the ovaries are packed about 6 ~ 9 cm higher than the top of the barrel. After the filling into the barrel, the layers of ovaries are pressed down with a wooden cover. When the wooden cover has sunk to the level of the top of the barrel, saturated NaCl solution is poured into the barrel through a small hole and the barrel is closed.

V. Technical Problems in the Curing of Fish or Fish Roe

1. Reddening of salted salmon

There have been many studies on the reported on the cause of reddening of salted fish. In the case of salted salmon, Hanzawa and Takeda(1) have isolated *Torula swehmeri* as the causual bacteria of the reddening of the surface. Takeda(2) has studied the relation between the growth of the reddening microorganism and the relative humidity. He reported that if the relative humidity is above 75 % in the storage room in which the reddening of salted salmon developed, the salt attached to the reddened salted salmon contains above 10 % of moisture. Thus if salted salmon is stored at room of above 75 % relative humidity, it may be reddened by the growth of this organism, because its salt content picks up over above 10 % of moisture. In order to prevent the reddening, the causual bacteria should be eliminated (by disinfection). At first all equipment and apparatus should be cleaned by disinfectants such as chlorine derivatives or others, and then it should be thoroughly washed with fresh water. Sometimes the equipment should be steam-disinfected.

The reddening microorganisms which come from sea water with the fish, should be removed or reduced in number by through washing. Even if the red pigment generates on the surface of fish which has been soaked in brine, it can not be seen or distinguished. Therefore the fish, after preliminary curing should be washed with fresh water and drained over night. The drained fish should then be cured regularly with new salt and placed in boxes. When the cured salmon is stored in a warehouse or cold storage, the relative humidity of the rooms should be less than 75 %, and the temperature should be lower than 37°C.

2. Antioxidants for salted fish

When fat-rich fish is cured and stored for longer than a month, the fat oxidizes and developes objectional odor. In order to prevent the oxidation, BHT (2,6-di-tertbutyl-p-cresol) or BHA (butylated hydroxyanisole, Sustane) are employed. An antioxidant such as "Linton C" (commercial name) (isoamylgallate + citric acid) is also sold in Japan. Those antioxidants are effective in retarding or preventing such oxidation.

Toyama et al.[3] have employed BHA for slack-salted salmon, and estimated the optimum amount of BHA for salmon to be 0.01 % of the weight of raw fish. In this case, it is best to mix BHA with the added salt. A mixture of BHT (0.0025 ~ 0.005 %) and BHA (0.0025 %) is effective in maintaining good quality in salted salmon. These also reported that "Linton C" in a concentration of more than 0.0025 % of the weight of raw fish is effective for salted salmon but that the meat turns violet in color. Thus, this antioxidant is not recommended for use with salmon.

3. Preservatives for salted fish

Recently slack-salted fish has become more popular than the hard-salted product. However, slack-salted fish readily spoils so the addition of preservatives has been tried. Yamada et al.[4] added "nitrofrazon" (5-nitro-2-furfuryl semicarbazone) (cured with 15 % NaCl) at a concentration of 1/10,000 ~ 1/25,000 and found that salted whale meat did not putrefy for two weeks at 22 ~ 25°C.

Konno et al.[5] have employed "nitrofrazon" on salted Atka mackerel (cured with 10 % NaCl), and found that it preserved the fish for 12 days at 12 ~ 13°C compared with untreated salted fish which putrefied within 28 days. However, "nitrofrazon" can not be used for salted fish. Recently the use of C.T.C. (Chlortetracycline) on raw material from which processed foods are made (e.g. canned food or fish paste) has been permitted. Its use for salted fish is not yet permitted, but it will probably be permitted in future, because almost all of the slack-salted fish except salted fish roe is eaten after baking or broiling. C.T.C. is decomposed during cooking thus making the product safe for human consumption.

4. Manufacture of salted-dried squid

Most of salted-dried squid is consumed in country side, even the production decreasing gradually depending on the change of food habits of this side. Motohiro et al.⁽⁶⁾ have studied the manufacture of salted dried squid in order to obtain a scientific standard of raw material, condition of procedure and preservability of the product. Results throughout the study show that the limit of freshness of raw material allowed V.B.N. below 20 mg %. The amount of sodium chloride penetrated into squid meat, reaches to the state of equilibrium needing about 9 hours after soaking brine. The amounts of sodium chloride in squid meat at the equilibrium were 3.8 %, 8.8 %, 13.6 % in the case of the soaking in 5 %, 10 % and 15 % sodium chloride solutions, respectively. The preservability of salted dried squid is governed by its degree of drying, but not sodium chloride content. The storing period of salted dried squid may be presumed to indicate from the drying degree, sodium chloride content and temperature in leaving period after drying.

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FERMENTED MARINE FOOD PRODUCTS

I. Definition and Classification

From ancient times, there have been certain fermented food products which are considered to be rather specialities of Japan: fermented marine foods ("shiokara"), cured-fermented marine foods ("tsukemono"), and fermented fish sauce ("gyoshoyu"). The fermented foods are prepared by fermenting fish meat or fish visceral mass (roe or milt and other parts of the visceral mass) spoilage being prevented by the addition of salt. Of the fermented marine foods, the products of squid meat ("ika-no-shiokara") and bonito visceral mass ("katsuo-no-shiokara") are famous in Japan.

The cured-fermented marine foods are prepared by fermenting fish meat or roe in boiled rice (fermented-"sushi"), in "koji" ("koji-zuke"), in rice-bran ("nuka-zuke"), in "sake"-lees ("kasu-zuke"), or in vinegar ("su-zuke"). The name of the products are different according to the species of fish or the part of the fish body used respectively. For example, "ayu-sushi" is prepared from "ayu" fermented in boiled rice. Other fish are also employed for "fermented-sushi".

Another fermented food beside the fermented foods described above, is fermented fish sauce. This product is prepared by continuing the fermentation of the fermented foods more than one year, during which time the fish meat or visceral mass becomes liquefied.

1. Kinds of fermented foods

There are many varieties of foods prepared by the fermentation of fish meat, roe, milt or visceral mass. They may be summarized as follows:

a) Fermented squid meat: Squid (*Ommastrephes sloani pacificus*) meat and the visceral mass (liver) are fermented together, spoilage being prevented by the addition of salt (about 15 ~ 20 %).

b) Fermented bonito visceral mass: Fish visceral mass (especially, the pyloric appendage) of bonito (*Katsuwonus pelamis*) is fermented with sufficient salt to prevent spoilage. This is the most frequently eaten by heavy drinkers under the name of "shu-to" ("sake"-robbery which means to promote drinking) in Japan.

c) Fermented sea-urchin ("uni-no-shiokara"): The roe or milt of the sea-urchin are fermented with salt to prevent spoilage. When the fermented sea-urchin is drained and kneaded, the commodity is called "neri-uni" (kneaded sea-urchin).

d) Fermented "ayu": This product is famous for its delicious taste and it has been liked by drinkers from ancient times. There are several kinds: "uruka" (fermented meat of "ayu"), "ko-uruka" (fermented roe), "shiro-uruka" (fermnted milt), "niga-uruka" (fermented visceral mass excluding roe and milt), "kirikomi-uruka" (fermented mixture of muscle meat and visceral mass).

e) Fermented visceral mass of the sea-cucumber

f) Fermented roe of crabs

g) Fermented visceral mass of abalone

h) Fermented *Calanus blumchrus* ("ami-shiokara")

There are also many other products made by fermenting mollusc meat (shellfish meat), roe or visceral mass of other fishes.

2. Kinds of cured fermented marine foods

Various kinds of cured fermented marine foods are marketed as follows:

a) "I-sushi" (cured fermented in boiled rice)

1) "Ayu-sushi", 2) "funa-sushi", 3) "tai-sushi", 4) salmon-"sushi", 5) flat fish-"sushi", 6) herring-"sushi" etc.

b) "Koji-zuke" (cured fermented in "Koji" which is prepared by inoculating *Aspergillus oryzae* on steamed rice and grow it).

1) "Ayu-no-koji-zuke" ("ayu" in "Koji"), 2) mackerel in "koji", 3) herring in "koji", 4) squid meat in "koji", 5) mackerel-roe in "koji".

c) "Nuka-zuke" (cured-fermented in rice-bran)

1) sardine in rice-bran, 2) herring in rice-bran, 3) globefish in

rice-bran, 4) globefish-roe in rice-bran

d) "Kasu-zuke" (fermented in "kasu" which is "sake"-lees)
  1) "Ayu-no-kasu-zuke" ("ayu" in "sake"-lees), 2) abalone meat in "sake"-lees, 3) cod meat in "sake"-lees, 4) salmon meat in "sake"-lees

e) "Suzuke" (vinegar-pickled)
  1) Sardine, herring, or mackerel meat in vinegar, 2) Alaska pollack meat in vinegar, 3) octopus or squid meat in vinegar

3. Kinds of fermented fish sauce

This product is prepared by continuing the fermentation of the fermented fish meat for longer than one year. "Shottsuru" which is prepared from "hata-hata" (sand fish, *Arctoscopus japonicus*) is the most famous product. Products from squid visceral mass, sardine, anchovy or other mollusca meat are also prepared, though the amounts of production are small.

II. Production of Fermented Marine Foods

The production of fermented marine foods from 1962 to 1968 is shown in Table 7-1.

Table 7-1. Production of fermented marine foods (tons) (1962～1968)

	Fermented marine products ("shiokara")			
	Sea-urchin	Squid meat	Others	Total
1962	1, 543	8, 697	1, 854	12, 094
1964	1, 887	6, 921	2, 397	11, 205
1965	2, 080	7, 652	3, 300	13, 832
1966	2, 327	7, 214	3, 084	12, 625
1967	1, 258	8, 910	2, 722	13, 890
1968	1, 615	9, 136	1, 973	12, 724

The main places of production of such products are Hokkaido, Miyagi, Kanagawa, Toyama, Ishikawa, Shizuoka, Yamaguchi, and Saga Prefectures.

The production of some kinds of fermented marine products increased recently owing to the employment of plastic film containers. The production of others has gradually decreased. A decrease in the catch of raw material from which the fermented foods are prepared is the main cause, but the decline of the public fancy for such salty foods in cities is another cause. However, the demand for fermented sea-urchin roe will be increased if the catch increases.

III. Fermented Marine Foods

Fermented marine foods are prepared from many kinds of fish. Such products are prepared by fermenting fish meat or visceral material (roe or milt and other parts of the visceral mass) spoilage being prevented by the addition of 15 ~ 30 % of salt by weight according to the production seasons.

When fish meat is employed to prepare the products, it is cured with salt in company with liver or other parts of the visceral mass. This is done because the autolytic enzymes in the muscle meat are weak, therefore it is necessary to add the liver or other visceral material having strong proteolytic action. As to the fermented squid meat, Nagao and Kimura(1) have reported that at about the 20th day from the beginning of curing the meat is decomposed by the proteolytic action of added liver and autolytic enzymes of the squid meat to form amino acids. After 20 days the decomposition may be caused by bacterial action with the formation of ammonia. The amino acids, especially mono-amino acids (α-amino acids), give the good flavor and taste to the fermented squid meat.

An example of the changes in the chemical components in fermented squid meat during fermentation is shown in Table 7-2. It may be seen that the amount of mono-amino acids increases with the progress of fermentation.

Okuda(2) has studied the increase and decrease in amounts of protein and amino acids in fermented bonito visceral mass ("katsuo-no-shiokara"). According to his observations, during the fermentation of the visceral mass of bonito, the amounts of protein and organic basic nitrogen decreased and the amount of non-protein nitrogen, especially mono-amino acids increased. The increase in the amount of mono-amino acids was quite significant. The development of good flavor and taste attributed to this increase of mono-amino acids in the fermented products. As an example, the changes of chemical components in the fermented visceral mass of bonito are reported by the above author are shown in Table 7-3.

Table 7-2. Chemical changes in fermented squid meat during curing

Sample	Time of curing	Total amount of soluble nitrogen (%)	Soluble protein nitrogen (%)	Non-protein nitrogen (%)	Basic nitrogen (%)	Mono-amino nitrogen (%)	Ammonia nitrogen (%)
(A) Amount of salt added as 10 %	After 6 days	1.131	0.360	0.771	0.492	0.279	0.011
	〃 16 days	1.433	0.315	1.118	0.720	0.398	0.048
	〃 104 days	1.991	0.213	1.778	0.785	0.993	0.329
(B) Amount of salt added as 15 %	After 6 days	1.144	0.295	0.849	0.672	0.176	0.006
	〃 16 days	1.305	0.315	0.991	0.750	0.240	0.031
	〃 104 days	1.850	0.313	1.537	0.752	0.785	0.087

1. Preparation of fermented squid meat

There are several preparations of fermented squid meat: ordinary fermented squid meat, red fermented squid meat, black fermented squid meat, and white fermented squid meat.

a) Ordinary fermented squid meat

Common squid (*Ommastrephes sloani pacificus* = *Todarodes pacificus*) is the principal source of raw material, but other squid (e.g., "hotaru-ika", (*Watasemia scintillans*)) are also used. The belly side of the mantle-cartilage of the squid is split from the neighbourhood of the infundibulm to a point distant from the end of the mantle-cartilage by means of a knife with the edge held upward. The ink sac and liver are removed without damage. The mantle-cartilage and cephalopodium

Table 7-3. Changes of chemical components in fermented visceral mass of bonito ("Katsuono-shiokara") during fermentation (Okuda(2))

Days after the curing Components	3 days	6 days	12 days	25 days	40 days
Water-content (%)	64.95	64.78	64.58	64.25	63.99
Dried matter (%)	35.06	35.23	35.43	35.75	36.01
Total amount of nitrogen (%)	1.98	2.04	2.05		2.07
Protein-nitrogen (%)	0.35	0.35	0.28	0.26	0.14
Ether-extractive matters (%)	1.83	1.81	1.81	1.71	1.74
Soluble matters (%)	27.25	28.45	29.24	31.10	31.14
Non-protein nitrogen (%)	1.63	1.69	1.83	1.98	2.01
Organic basic and ammonia nitrogen (%)	0.99	0.97	0.94	0.81	0.77
Ammonia nitrogen	0.15	0.15	0.25	0.18	0.13
Organic basic nitrogen (%)	0.84	0.72	0.69	0.63	0.64
Other kinds of nitrogen	0.74	0·80	1.09	1.17	1.43
Total amounts of acids	1.43	1.42	0.77	0.96	0.98
Amount of NaCl	17.30		17.34		17.71

are separated and thoroughly washed in dilute salt solution. After draining the mantle-cartilage is cut in rectangular strips (3～4×0.5cm) by hand or by a machine. The head is split at the central line to remove the jaws and eyes. The cephalopodium of which the head is split is cut in 2～3 cm lengths at right angles to the podium. Before cutting, the cephalopodium is rubbed with salt by hand to remove horny rings in the suckers. One hundred parts of meat strips, 4～8 parts of the liver content which has been removed and 30 parts of salt in summer (15 parts of salt in winter) are mixed together in a barrel and stored in a room. During the first week, the mixture is stirred two or three times a day. The barrel is then sealed tightly. If too large an amount of liver is added to the strip meat, the meat will be autolyzed too early, on the other hand, if too small an amount of liver is added, the meat will be autolyzed too slowly and less of the flavor components will be produced. The moderately autolyzed mixture is packaged in some small bottles for the market.

b) Black fermented squid meat ("kuro-zukuri")

Black fermented squid meat is specially produced in Toyama Prefecture. The mantle-cartilage is separated from the cephalopodium and is skinned with a knife. Then the mantle-cartilage and the body is slit into two layers. Each layer is cut into strips. The strip meat is mixed with 2 ~ 4 % of the natural black ink and liver and 20 % of salt by weight in a barrel. The mixture is stored with stirring two or three times a day for week. The resulting product is black and it is favorite with "sake" drinkers.

c) Red fermented squid meat

This product is also a special product of Toyama Prefecture. The cephalopodium of squid removed from mantle-cartilage is cut into small pieces. The cut meat is mixed with 2 ~ 4 % liver and 20 % of salt by weight and fermented for one week. The red color of the product is caused by the presence of a relatively large amount of liver.

d) White fermented squid meat

This product is produced in a few places in Japan. The mantle-cartilage is skinned and cut into strips as before. The cut meat is cured with salt and small amount of liver. The meat does not change to red, but is white, because the chromophores have been removed with the skin.

2. Fermented bonito visceral mass

Fermented bonito visceral mass is prepared from the visceral mass removed in the processing of bonito-"fushi" or of canned bonito. The main places of production are Shizuoka, Kanagawa, Kagoshima, Chiba, and Fukushima Prefectures in which there are many sea ports for bonito-fishing. The people of Tokyo say that the product from Kanagawa Prefecture is the best in quality. The visceral mass obtained in summer is better than that in autumn, because the former contains less fat. Similarly that of the small bonito is better than that of large fish. If the fat content is high, it may oxidize and cause an astringent taste. There are several kinds of such products: from the meat, alimentary canal, milt or roe.

a) Ordinary preparation

From the visceral mass of bonito the gall bladder is removed. The pyloric appendage and alimentary canal are split with a knife and the contents removed. The visceral mass is soaked in fresh water to remove fatty substances and other materials. After draining, the visceral mass is placed in a barrel with 20 ~ 30 % salt by weight. Sometimes the visceral mass is cut in pieces 3 cm long. In the initial period, the mixture must be stirred two or three times per day for a week, afterwards once per day. The water liberated from the visceral mass should be removed. After the fermentation, the product is sold in small bottles or other containers. Sometimes, during the fermentation of bonito visceral mass, sugar is added in order to redden. Sometimes, "sake"-lees or "koji" is added to the mixture in order to sweeten. The fermented bonito visceral mass is filled into glass bottles. It sometimes generates carbon dioxide gas, if a carbohydrate such as "koji" is added. To prevent the bursting of the bottle by the generation of gas, a slight amount of diluted alcohol is added to the product.

b) Fermented bonito meat ("mi-kara")

"Mi-kara" is prepared from the cut meat of bonito, of which the fat-content is low. Salt is added in the amount of 20 ~ 30 % by weight.

c) Fermented stomach ("i-kara")

This product is prepared only from the stomach of the bonito. The preparation is the same as the ordinary procedure.

3. Fermented sea-urchin

Amongst the sea-urchins, horse-dung sea-urchin ("bafununi"; *Stroogylocentrotus purcheriimus*), red sea-urchin ("akauni"; *Psudocentrotus depressus*) and purple sea-urchin ("murasaki-uni"; *Heliocidaris crassispina*) which inhabit the waters surrounding Japan are employed in the preparation of fermented products. The spawning season of these sea-urchins is from June to September. Three kinds of fermented are prepared commercially from sea-urchins: "mizu-uni" (watery fermented sea-urchin), "doro-uni" (pulpy fermented sea-urchin) and "neri-uni" (pasty fermented sea-urchin).

a) "Mizu-uni" (watery fermented sea-urchin)

The shell is split in two at the equatorial line with a knife. The yellow ovary (brownish red at spawning period) or yellowish white testes accompanied by the body fluid is removed and placed in a small wooden tub. The spines of sea-urchin are easily broken. If broken pieces of spine are mixed in the reproductive organs, they must be removed with a pincette. Blood vessels and extraneous material are carefully removed. Salt is added to each layer of the reproductive organs spread on the bottom of the tub. The total amount of added salt is 30 ~ 40 % of the weight of the reproductive organs. The tub is closed tightly with a lid and is stored in a cold place to ferment slowly.

b) "Doro-uni" (Pulpy fermented sea-urchin)

Purple sea urchin is the best raw material for this product. "Ezo-bafun-uni" (*Strongylocentrotus intermedius*), and red sea-urchins are also employed. The reproductive organs are taken from the shell by splitting, and are washed with diluted alcohol in a dish, after which they are drained. The drained material is mixed with 25 ~ 30 % by weight of salt. The mixture is stored in a cold place.

c) "Neri-uni" (Pasty fermented sea-urchin)

This product is a specialty in Fukui, Yamaguchi and Hokkaido Prefectures. This is the most expensive of the fermented marine products in Japan. The best raw material is purple sea-urchin, but red sea-urchin is also employed.

The shell is split with a hammer and the reproductive organs are removed and placed in a small tub, or into an open bamboo basket, which is shaken slowly in a water tank to wash the organs. Floating extraneous substances are carefully removed. The basket is then taken from the water and drained. The draining is the most important procedure. The drained material is spread over a dressing table on which salt has been sprinkled. The organs are covered with salt by means of a bamboo spatula. The amount of salt used differs according to its quality, the season, and the freshness of the raw material from the sea-urchins, but it is about 20 ~ 30 % by the weight of the organ. The organs covered with salt are spread on a bamboo blind to drain thoroughly for several hours. The drained organs are then put in a barrel or vessel, which is closed with a lid. When the product is sold, the cured organs are kneaded carefully with a bamboo spatula. If foreign material is found in the paste, it must be removed. When the cured material is sufficiently kneaded, the paste is put into small glass bottles of 75, 188 or 375 g net weight, respectively. In a recent modification of the process the cured organs are kneaded in a mixer, after which the material is seasoned with sugar, "sake"-lees or sweet "sake" in a barrel and the fermentation is continued.

4. **Fermented sea-cucumber viscera** ("konowata")

This product is prepared by fermenting the visceral mass, especially the intestine of sea-cucumber (*Stichopus japonicus*). This product, as is fermented sea-urchins, is liked by drinkers, and is very expensive. The product prepared in Aichi Prefecture has the best quality. Aichi, Hokkaido, Aomori, Kyoto, and Mie Prefectures are principal places of production. The producing period is December to the following March. In the visceral mass which is removed, the respiratory tree organ is yellowish and is distasteful, so it is removed from visceral mass with a knife. The longer the alimentary canal, the more expensive the product. In Aichi Prefecture, sea-cucumber is split at the ventral side and the visceral mass is taken out.

The visceral mass (alimentary canal and reproductive organs) is washed thoroughly in sea water and the contents of the alimentary canal are pulled out with the fingers without breaking the canal. Sometimes the alimentary canal is split carefully with a knife. The washed visceral mass is drained in a bamboo basket with the addition of one third of the total amount of fine ground salt. After draining, the remaining two thirds of salt is added to the visceral mass in the basket. The total amount of salt used is 10 ～ 15 % of the weight of the raw visceral mass. The mixture is stirred frequently with a thin stick for 5 1/2 hours. When the drained water stops dripping, the mixture is put into a barrel and it is covered with a lid. If the stirring is continued for a week, the fermentation will advance moderately, and the resultant product is of the best taste. Even if such mixture is stored over 2 ～ 3 weeks, it does not spoil. The finished product is sold in small glass bottles.

In Hokkaido, the fishing period is in summer, therefore the visceral mass removed in the processing of the "dried sea-cucumber" must be kept in cold storage until processing can be completed during the winter.

5. **Fermented "ayu"** ("uruka")

Fermented "ayu" (*Plecoglossus altivelis*) is called "uruka" in Japan. There are five kinds of finished product: fermented roe ("ko-uruka"), milt ("shiro-uruka"), meat and visceral mass ("kirikomi-uruka") and a mixture of roe and milt ("torimaze-uruka"). The various kinds of fermented products from "ayu" are produced in places where "ayu" is caught; especially Gifu Prefecture which is a famous place of production. Fermented "ayu" products are very expensive in Japan.

a) Fermented "ayu" roe ("ko-uruka")

This product is prepared by fermenting the roe of "ayu". To one part of roe is added 0.3 parts of good quality salt in a barrel. Every day the mixture is stirred several times.

b) Fermented milt of "ayu" ("shiro-uruka")

This is prepared by fermenting the milt of "ayu" similarly to the procedure with roe.

c) Fermented mixture of roe and milt ("torimaze-uruka")

This is prepared by fermenting a mixture of milt and roe in a barrel in the same way as roe.

d) Fermented visceral mass of "ayu"

The visceral mass removed from the body of "ayu" is washed thoroughly with fresh water to remove the contents of the alimentary canal. After washing the visceral mass is fermented with the addition of salt in the same way as roe.

e) Fermented meat and visceral mass of "ayu"

The body of "ayu", from which head and fins are removed is cut finely. On the other hand, the visceral mass is also cut finely after washing. The fermentation is carried out in the same way as that of roe.

IV. Liquid Fermented Fish Sauce

Liquid fermented fish sauce is prepared by continuing the fermentation of the fermented fish meat for more than a year. This product is prepared from various kinds of fish, mollusca or their visceral mass: e.g., sand fish ("hata-hata", *Arctoscopus japonicus*), sand lance ("ika-nago", *Ammodytes personatus*), anchovy, oyster, baby clam, and visceral mass of salmon. Among those products, the fermented sand fish ("hata-hata") sauce which is produced in Akita Prefecture is called "shottsuru" and it is the most famous.

The preparation of fermented sand fish sauce ("shottsuru") is as follows. The head and fins of sand fish are removed with a knife and the visceral mass is taken out. The fish body is washed thoroughly with fresh water, and is drained. The drained fish body is cured with salt and "koji" in a barrel and the mixture is pressed under the weight of a stone; it is then stored in a cold place for about a year. After a year, the mixture is stored with occasional stirring for about six months without a weight. After the fermentation has been completed, the mixture is filtered through a cloth bag with pressure. The liquid filtered out is boiled and then stored for more than 7 years. The stored liquid is filtered again before being bottled for sale. The liquid (fish sauce) is sold in bottles of 500 cc or 1,000 cc content. This fish sauce is used in boiling vegetables with white flesh fish meat. The fish sauce is sometimes further processed into fish-"shoyu". The processing is as follows: To the fermented fish sauce is added soy-bean sauce lees or wheat "koji" to give "shoyu" fragrance. The mixture is filtered with a cloth bag. Recently, Asano and Ōno [3] studied a rapid method for the preparation of fermented sand fish sauce ("shottsuru"). They found that a proteinase ("pronase") is most effective to prepare the product among various enzymes. Tanikawa and Matsuura [4] have studied the manufacture of the liquid fermented fish sauce with salmon viscera as raw material. The salmon viscera was added with sodium chloride in 3 % concentration and with king crab liver in 10 %, then allowed to stand for 40 days, heated for 30 minutes at 100° C, and adjusted pH 6.2～6.6. The chemical composition of the product are shown in Table 7-4.

Table 7-4. Chemical compositions of the liquid fermented fish sauce prepared from salmon viscera.

Items \ Sample No.	1	3	5	7
pH	4.8	4.7	4.6	4.7
Specific gravity	1.15	1.49	1.15	1.13
Total-N (%)	1.67	1.64	1.62	1.58
Amino-N (%)	0.91	0.82	0.88	0.73
Salt (%)	17.6	17.4	16.1	16.1

V. Fermented Fish Paste

Tanikawa et al.(5) have investigated the manufacture of fermented fish paste ("gyomiso") instead of soy beans. To manufacture the product, crushed fish meat (75 %) is mixed with wheat bran (10 %) inoculated with *Aspergillus oryzae* and salt (15 %). This mixture is kept about 2 weeks at 25～30°C to ripen by the action of the auto-digestive enzyme of fish meat and the action of the enzymes of *Asp. oryzae*. After 2 weeks the mixture should be cooked to stop the action of enzymes. For 3 days after the mixing of fish meat, wheat bran and salt, the mixture was too hard to disturb, but after the 4 th day the mixture become soft. On the 5 th day, a bag which was filled with Japanese cedar wood dust was immersed into the mixture, then the mixture gave off the cedar flavour. From the 7 th day, the fermentation of the mixture become stronger, and the juice increase. The pH value of the mixture is 6 at the beginning, pH 6.5 during the fermentation and become pH 4.5 at the end of the fermentation. If the fermentation goes on excessively, the pH value becomes greater than 6.5 and at this time ammonia smell is given off. Therefore, when the mixture indicates pH 5.5, it should be boiled to sterilize it, and to decrease the water content of the goods to 40 %. And then it blends homogeneously together. The percentage of yield of the products is from 45 to 50 % of the weight of the raw fish bodies.

VI. Cured Fermented Marine Products

1. **"I-sushi"** (fermented-"sushi")

The products of fermented-"sushi" are the old style Japanese-"sushi" of today ("nigiri-sushi"). The product is prepared from "ayu" (*Plocoglossus altivelis*), "funa" (prussian carp; *Carracius auratus*), "tai" (sea bream; *Pagrosomus major*), sand fish (*Arctoscopus japonicus*), "bora" (mullet; *Mugil cephalus*), salmon, etc. The procedure is different according to the place of production and kind of fish meat employed.

Generally speaking, fish bodies from which visceral mass has been removed are cured with 20 ~ 30 % of their weight of salt. In particular the ventral cavity is filled with salt. The cured fish bodies are stored under a stone weight for one to two months. After the cured fish is desalted, the bodies are drained. Boiled rice and "koji" are sprinkled at the bottom of a barrel, and then the desalted fish bodies are placed on the layers of boiled rice and "koji"; the ventral cavity is also filled with boiled rice and "koji". The amount of boiled rice added is about 40 ~ 50 % of the fish material, and that of "koji" is a half that of the boiled rice. The filled barrel is pressed with a weight. The fermentation will be completed after 10 days. It has the best taste after two months of fermentation.

The fermentation is mainly lactic. According to Matsushita(6), *Lactobacillus sp.* grows actively at the beginning of the curing, but with the advance of fermentation the number of *Lactobacilli* decreases, but on the other hand, yeasts are survive for a long time. Matsushita has isolated *Streptococcus faecium, Lactobacillus planatarum* and two kinds of *Lactobacillus pentoaceticus* during or after the curing of fermented prussian carp-"sushi". The last two species have an important role in the fermentation. The special flavor and taste of fish-"sushi" is due to the formation of basic substances such as ammonia, cadaverine, piperidine, trimethylamine and volatile acids such as lactic, valerianic, butyric, propionic, acetic and formic, plus the added salt. The lactic acid and alcohol formed in the fermentation of the cured fermented foods plus residual salt appear to be adequate to prevent the spoilage of fish-"sushi". The changes in chemical composition during curing

Table 7-5. Changes in chemical composition during curing fermentation of prussian carp-"sushi" ("funasushi") (Matsushita(6))

Chemical component (%)	Raw prussian carp meat			After curing with salt			After curing in boiled rice		
	Raw fish meat	dried sample	dried matter	Raw fish meat	dried sample	dried matter	Raw fish meat	dried sample	dried matter
Water-content	73.23	4.36	—	79.02	3.68	—	72.52	6.62	—
Dried	26.77	95.64	100	20.98	96.32	100.0	27.48	93.38	100
Crude protein	15.66	59.42	62.13	16.03	84.70	50.56	14.38	48.88	52.34
Pure protein	—	46.35	48.46	—	33.10	34.36	—	36.13	38.69
Water soluble mater	—	14.25	14.90	—	25.75	26.73	—	20.75	22.22
Water soluble protein	—	2.63	2.63	—	1.68	1.74	—	2.01	2.22
Carbohydrate	—	—	—	—	—	—	—	3.25	3.48
Ether-extractive matter	4.26	16.22	16.96	2.52	11.59	12.03	5.97	20.30	21.70
Ash	1.17	6.22	6.59	2.02	9.64	10.01	2.0	7.12	7.62
Acid (as lactic acid)	—	—	—	—	—	—	2.0	6.85	7.33
Gelatine forming protein	—	26.18	27.35	—	18.98	19.69	—	23.52	25.18

and fermentation of prussian carp-"sushi" ("funa-sushi") are shown in Table 7-5.

Food poisoning by eating herring meat-"sushi" ("nishin-i-sushi") happened for the first time in 1951 in Hokkaido, Japan. The cause of the poisoning was ascertained by Nakamura, Iida and Saheki(7) to be *Cl. botulinum* type E. The cause of the growth of this bacterium was found to be due to the careless preparation of "sushi" by housewives in the hot season. Poisoning by "sushi" prepared as a commercial product has not been known to occur.

a) "Ayu-sushi" in Kanagawa Prefecture

The bodies of "ayu" are split at the ventral side to remove the visceral mass and back bone. The gills are also removed. The split bodies are washed thoroughly, and then are initially cured with about 30 ~ 35 % of salt by weight. The cured fish bodies are pressed under a stone for 10 days. When the liberated water has reached to the top of the barrel it is removed. The cured fish bodies are salted again stored under stone weight. For the preparation of "sushi", the cured fish bodies are desalted in cold fresh water for 10 ~ 18 hrs. according to their size. The desalted fish is soaked in vinegar for 15 minutes after which it is cured for 10 days with boiled rice layer by layer in a barrel. The cured fish is sold with the rice attached to the fish.

b) "Ayu-sushi" in Toyama Prefecture.

The bodies of "ayu" are split at the ventral or back side to remove the visceral mass and gills. One hundred fish bodies are mixed with salt of 0.3 ~ 0.4 kg weight and the mixture is stored for 24 hrs. After this salting, the back bone is removed with a knife. One hundred cc. of rice vinegar (5.3 % acetic acid content) are sprinkled on the fish. After about one hour the vinegared fish is cured with boiled white rice in a barrel. Boiled rice is on the bottom of a barrel and covered with bamboo leaves. On the bamboo leaves the vinegared fish is spread, and then boiled rice is piled rice is piled in layers and bamboo leaves also spread. Additional vinegar is then sprinkled on the bamboo leaves. (The amount of vinegar is 400 cc. for 100 fish). The layers of the mixture of vinegared fish, rice and bamboo leaves are pressed under wooden lid with a stone. The cured and fermented fish is sold with the rice attached.

c) "Funa-sushi" in Shiga Prefecture

The same cured product in boiled rice is produced in Fukushima Prefecture (Lake Inawashiro or Hinoegi district), and(Yamamoto district) besides Shiga Prefecture. Here, the method of preparation in Shiga Prefecture will be described. Female prussian carp (*Cyprithus auratus*) of which the reproductive organs have matured at beginning of summer is the best raw material. The scales and gills are removed. The fish bodies are split to remove the visceral mass and they are washed thoroughly. The head and back bone should not be removed. The washed carp bodies are cured with about 20 % by weight of good quality salt in a barrel for one month. The salted carp is pressed with a stone of 16 ~ 20 kg. After the curing, the bodies are desalted in fresh water and drained. At the bottom of another barrel, boiled rice is sprinkled after cooling. On the rice layer desalted carp bodies are spread in a layer and then rice is sprinkled. The top layer of rice is covered with parchment paper or bamboo leaves and a lid is placed on the barrel, on which a weight (stone) of about 150 kg is placed. After curing for 3 ~ 4 months, the fish and rice are eaten.

d) Cured salmon-"sushi"

In the Tohoku district raw salmon is employed and in Hokkaido salted salmon is used. At present the Hokkaido style product is mainly produced.

Hard-salted salmon is desalted, and the head and fins are removed. The fish bodies are cut diagonally in small pieces (about 1 cm thick). Boiled rice after cooling is sprinkled at the bottom of a barrel. On the rice layer the small pieces of desalted salmon are placed with finely cut vegetables (carrot, cabbage or giant radish). Bamboo leaves are placed on the mixture to cover. Rice is then sprinkled as a layer. Sometimes between each layer of fish bodies "koji" is added. The amount of boiled rice is 30 % of the weight of the fish bodies. The amount of "koji" is 10 ~ 15 %. After the arrangement of the last layer, the lid is placed on the barrel, and the lid is pressed with a weight (15 ~ 20 kg of stone). After 30 days' fermentation, the material is considered to be of best quality.

e) Cured Atka mackerel or flat fish in boiled rice

Cured Atka mackerel or flat-fish in boiled rice is prepared in the same way as cured salmon.

f) Cured squid meat in boiled rice

In Hokkaido squid meat is also cured in boiled rice at home. The cephalopodium is removed with visceral mass from the mantle-cartilage of squid. Mantle-cartilage is washed thoroughly and then it is boiled in dilute salt solution. After boiling the epidermis of the mantle-cartilage is removed. The mantle-cartilage is cured at first with salt, 15～20 % by weight, for several days. After the salt-curing, the mantle-cartilage is desalted moderately in fresh water. On the bottom of a barrel, boiled rice is sprinkled as a layer after cooling. The desalted mantle-cartilage is placed to cover the rice layer. Cut vegetables (carrot, radish or cabbage etc.) and "koji" are sprinkled over the layer of mantle-cartilage. The making of layers of rice, squid, and vegetables is repeated. The last layer of rice is covered with parchment paper and a lid is placed on the barrel. The lid is pressed with a weight (stone). After fermentation for 20 ～ 30 days, the cured product is eaten.

2. **Cured products in "koji"** ("Koji-zuke")

Cured products in "koji" are prepared from various kinds of fish, mollusca and their roe. For example, "ayu", sea-bream, mackerel, anglerfish, herring, octopus, squid, mackerel roe, etc. The common method for the preparation of the cured products in "koji" is as follows. Fish or roe is first cured with salt. After removal of the liberated liquid, "koji" is added to the salted fish or roe and the material is fermented for some period. Protease in "koji" ferments the meat or roe protein during the storage giving good flavor and taste.

a) Cured "ayu" in "koji"

"Ayu" (*Plecoglossus altivelis*) which is caught in August ～ September is the best raw material. Round "ayu" is cured with good quality salt of about 20 % by weight for one day in a barrel. After curing, the liberated liquid is removed. In another barrel, the salted "ayu" is cured with "koji" of 50 ～ 60 % by weight of the raw fish. For selling, the fish is packed and sold in small glass bottles or wooden boxes.

b) Cured sea-bream in "koji"

This product is specially produced in Yamaguchi Prefecture. Fresh sea-bream is split at the back side, and thoroughly washed. The drained fish is cured with salt of 20 % by weight. The salted fish is sliced in piecies of 1 cm thickness. The sliced fish pieces are cured with "koji", 30 ~ 40 % by weight of the raw fish, in a barrel or in a big glass bottle.

c) Cured mackerel in "koji"

Fresh mackerel is beheaded. Then the body is split at the back side to remove visceral mass and back bone. The split fish bodies are washed thoroughly and drained. After draining, the bodies are cut into 4 ~ 6 pieces which are cured with salt of about 20 % by weight for 2 ~ 3 days. After the removal of liberated salt solution the salted fish pieces are placed in a barrel and "koji" (40 ~ 50 % by weight which is saturated with "shoyu") is added. When the barrel is filled, the mixture is covered with bamboo leaves, and pressed under a weight. Bonito and tuna meat are prepared in the same manner as mackerel.

d) Cured mackerel roe in "koji"

This product of Fukui Prefecture is famous and well known throughout Japan. The roe removed from split mackerel is cured with 30 % by weight of salt in a barrel under a stone weight for 2 days. After the salting, the fish roe is washed thoroughly in fresh water and is drained. In another barrel "koji" is sprinkled as a bottom layer. On the "koji", roe is placed in a layer. The arrangement of layers is repeated. The amount of "koji" added is 30 ~ 40 % of the weight of the roe. After the barrel is filled a lid is put in place with a weight (stone of about 10 kg). After 4 days' curing, rice-washing water is added from the opening between the lid and the barrel side. After 50 days' storage the product is ready to eat.

e) Cured octopus or squid meat in "koji"

Bodies of fresh octopus are split to remove visceral mass: the split body and tentacles are boiled together in dilute salt solution. They are then cut into small pieces. The cephalopodium and mantle-cartilage of squid are separated. The mantle-cartilage which is employed for this product is boiled and then it is cut into small pieces. The pieces of octopus or squid mantle-cartilage are cured with salt and "koji". The amounts of salt and "koji" are 20 ~ 30 % respectively of the weight of the fish. Salting increases the firmness of the meat of octopus and squid and a good flavor is developed by the protease of the "koji". Abalone is also cured in the same way as octopus or squid.

f) Cured herring in "koji" ("nishin-no-koji-zuke")

Cured herring in "koji" is prepared in Hokkaido in the home. Dried herring ("migaki-nishin") is employed as the raw material. The dried herring is soaked in rice-washing water to soften for one day. After soaking, the fish are cut in small pieces 6 ~ 7 cm in length. On the bottom of a barrel salt is sprinkled, and half as much "koji" as salt is also sprinkled. Radishes, carrots or cabbage cut in small pieces are spread on the layer of salt and "koji". The pieces of softened herring meat are spread on the layer of vegetables. The ratio of the amount of herring and vegetables is 1 : 2. The arrangement of layers of salt and "koji", vegetables and herring meat is repeated to fill the barrel. The total amount of salt in proportion to the weight of the mixture of herring and vegetable is 15 ~ 20 %. The amount of "koji" is one half that of the salt. When a barrel is filled, the lid is pressed under a weight (stone of about 10 kg). After two months' storage, the product is eaten.

3. **Cured products in rice bran** ("Nuka-zuke")

In Japan from ancient times, giant radishes have been cured with salt and rice bran ("takuan-zuke"). "Takuan-zuke" is one of the important Japanese daily dishes. Fish or fish roe are also cured with salt and rice bran. For example, sardines or herring and globefish or its roe are cured in this manner. Fish meal or roe is employed after salt-curing or drying. The amount of salt added is sufficient to preserve the fish meat or roe and rice bran itself from spoilage. It is about 30 ~ 35 % by weight of the salt-cured or dried fish meat or roe. The amount of rice bran is 30 ~ 70 % the weight of the fish meat. During the fermentation of fish meat or roe and rice bran, the mixture must be pressed with a stone weight avoiding contact of the fish meat or roe with air.

There has been no scientific study on the preparation of cured fish or roe in rice bran. In the case of cured radish in rice bran, Otani[8] has discussed the relation between bacterial flora and chemical changes in the cured radish. He has isolated three kinds of yeasts (*Zygosaccharomyces nukamiso, n. sp., Saccharomyces sp., Torula nukamiso, n. sp.*), three kinds of film yeasts (*Hansenula anomala*, two kinds of *Mycoderma* and three kinds of *Lactobacillus* (*B. cucumeris fermentati, B. lindneri, B. helormensis*). He reported that in good quality cured radish in rice bran, yeasts and film yeasts, besides lactobacilli have been found, but in the abnormally acidified bran lactobacilli only have been found. From these observations, Otani has deduced that in the process of fermentation of radish cured in rice bran, yeasts from the rice bran decompose starch to sugar which may be consumed by bacteria and yeast. But he believed that at the beginning of the fermentation alcohol or esters which have been formed by yeasts will prevent the growth of bacteria; then the alcohol and sugar formed will be consumed by film yeasts. With the increase in lactic acid in the fermentation, lactobacilli grow actively and the yeast will be destroyed. He also observed that the alcohol, esters and moderate amount of lactic acid will give a good flavor to the cured products. Therefore, in the process of fermentation the growth of lactobacilli should be restrained corresponding to the growth of yeasts. In the process of the fermentation of rice bran, besides alcoholic or lactic fermentations, acetic or butyric fermentations occurs a poor flavor.

a) Cured sardine in rice bran

This product is very famous in Fukui Prefecture.

Fresh sardine which are caught in winter are beheaded with removal of the visceral mass. The fish bodies are then washed and drained. The drained fish bodies are cured with salt, 30 % by weight, for 1 ~ 3 days. The salted sardines are then washed with fresh water to remove extraneous substances. After washing the fish are dried outside in good weather for one day. The half-dried sardines are cured in a barrel with rice bran and "koji". The amount of rice bran is 30 ~ 50 % and that of "koji" is 15 ～ 25 % of the weight of the sardines.

At first the rice bran and "koji" are sprinkled at the bottom of the barrel. On the layer of rice bran and "koji", sardines are spread as a layer. Then about 150 cc of Japanese "sake" is poured on the sardine layer. Then rice bran and "koji" are sprinkled. Thus the barrel is filled with the mixture, a lid is used, on which a stone weight (about 20 kg) is placed. After 5 days, saturated NaCl solution is poured into the barrel and the lid is pressed with a weight of stone (about 37 kg). The product is ready to eat about four months after the start of curing.

b) Cured herring in rice bran

Raw herring or dried herring meat ("migaki-nishin") are employed. Raw herrings are beheaded and split at the ventral side for removal of the visceral mass. The tail is also removed. The dressed herring are cured in a barrel with 20 ～ 22 % of salt and 6 % of rice bran by weight. After 5 days' curing, 8 % salt and 4 % rice bran are added again. The barrel is fitted with a lid, on which a weight of stone (about 10 kg) is placed. If the barrel is covered with parchment paper to prevent flies, it can be preserved for more than one year. When dried herring meat ("migaki-nishin") is employed, it is soaked in fresh water for 2 ～ 3 days to soften. The softened meat is washed thoroughly and then drained. Rice bran is made into a paste with saturated salt solution. The softened herring meat and the paste of rice bran are cured in a barrel. This product is eaten with the rice bran after boiling.

c) Cured globefish meat in rice bran

This product is a specialty in Ishikawa Prefecture. Dressed globefish are cured with 30 ～ 40 % by weight of rice bran in a barrel. Into the barrel liberated liquid from other salted fish (several kinds of salted fish) is poured. The barrel is covered with a lid, on which a stone weight is placed. After 4 ～ 5 years' storage the taste is the best.

d) Cured globefish roe in rice bran

This product is also a specialty in Ishikawa Prefecture. Roe taken out from globefish is washed thoroughly in fresh water and is cured for one day. After curing, it is dried on a bamboo blind for 3 ～ 4 days. The half-dried roe is cured with 50 % by weight of rice bran in a barrel to which liquid from other salted fish is added. The curing is carried out from March to May, and it is eaten after September. The toxin (tetradotoxin) of the reproductive organs of globefish is very toxic. The toxin is violent in the period from November to March. It is present most abundantly in visceral mass, especially in the reproductive organs. Migita and Hashimoto[9] have studied the presence of the toxin in the roe of globefish cured in rice bran. According to their observations the toxic activity in the roe decreased and contrarily that in the liquid separated from salted roe increased. Specifically, Table 7-6 shows the increase and decrease of toxicity of the cured roe of globefish after several days of curing.

Table 7-6. Increase and decrease of toxicity of the roe of globefish cured in rice bran (Migita and Hashimoto(9))

Procedure	Liquid separated during the curing	In rice bran attached to the roe	Roe of globe fish			
			No. 1	No. 2	No. 3	No. 4
Before salt-curing			4,900	2,800	2,600	3,100
After salt curing						
1 st day	2,600					
5 th day	3,400					
10 th day	3,200		5,800	2,400	3,600	4,100
20 th day	5,300		4,200	5,100	3,300	4.000
After curing in rice bran						
7 th day		1,900				
1 month		3,900	5,500	6,000	5,400	5,400
3 months		3,600	3,800	3,700	3,600	3,700
5 months		2,700	3,100	3,100	3,300	3.100
7 months		2,200	2,200	2,200	2,200	
17 months		1,000	1,000	1,200	800	

N.B. The values in the table show the weight of rat (g) which will be killed by toxin in 1 g of roe, separated liquid or rice bran cured; M.U. (Mouse Unit).

As seen in Table 7-6, the toxicity in cured roe in rice bran or in rice bran itself decreased with length of storage time. The toxic acivity in the separated liquid increased, therefore the liquid must

Table 7-7. Toxicity of commercial samples of globefish roe cured in rice bran (Migita and Hashimoto(9))

	Product	Weight or roe	pH	M. U.	Amount of salt	Remarks
A	Roe 1	200 g	5.3	610	14.4 %	"Mafugu" (*Sphaeriodes porphyreus*) 6 months after the curing
	Roe 2	152		630	14.2	
	Rice bran attached		5.3	390	17.6	
B	Roe 1	190		200	14.7	"Same-fugu"("Kana-fugu", *Sphaeroides inermis*) 6 months after the curing
	Roe 2	172		200	15.6	
	Rice bran attached		5.2	200	17.2	
C	Roe 1	226		280	14.3	"Ma-fugu" and "Sa-bafugu" (*Sphaeroides spadiceus*) 6 months after the curing in rice bran
	Roe 2	1,520		240	15.0	
	Rice bran attached		5.1	250	15.1	
	Roe 1			280	14.7	"One year after the curing in rice bran
	Roe 2	115		240	14.0	
	Rice bran attached		5.2	240	15.3	

be thrown away.

Data obtained by tests on the toxicity of commercial samples of cured roe of globefish in rice bran are shown in Table 7-7. As seen in Table 7-7, the toxicity (M.U.) in the cured roe decreased. According to Tani(10), the lethal amount of the toxin of globefish roe is 200, 000 Mouse Units. The units of from 200 to 700 as seen in Table 7-7 indicate a low level of toxicity. Unless more than 1 kg of such cured product is eaten at one time, it is safe to eat. Migita and Hashimoto(9) concluded that cured product of which fermentation is not completed, should not be eaten, and that during the procedures if the liquid separated from the salted roe is eliminated, it is not dangerous to eat.

4. **Cured fermented products in "sake"-lees** ("Kasu-zuke")

After fish meat or roe have been salted they are cured in "sake"- lees, or sweet "sake"- lees. The flavor and taste of the lees are transferred to the fish meat or roe and their taste becomes delicious. On the other hand, the fish meat or roe and autolyzed somewhat, becoming soft.

"Ayu", salmon, cod or abalone meat are employed as raw materials.

a) Cured fermented "ayu" in "sake"-lees ("Ayu-no-kasuzuke")

"Ayu" (*Plecoglossus altivelis*) is split on the back side for removal of visceral mass. The fish are then washed thoroughly and drained. The drained fish are cured with 20 % by weight of salt for 10 days. After this salting treatment the fish are washed with fresh water and especially the ventral cavity is washed thoroughly. The washed fish are then cured with "sake"-lees (or sweet "sake"-lees) in a barrel. The weight of "saka"-lees is about the same as that of the cured fish.

b) Cured salmon or cod meat in "sake"-lees ("Sake-no-kasuzuke" or "tara-no-kasuzuke")

Salted salmon or cod meat fillet are cured with "sake"-lees added is equal to the weight of the salted fish meat.

c) Cured fermented abalone in "sake"-lees ("Awabi-no-kasuzuke")

The meat of abalone is removed from the shell and cured in a barrel for one day with about 10 % by weight of salt. During the salt-curing, the barrel lid is pressed with a weight. After the curing the meat is washed with dilute NaCl solution and is drained on a bamboo blind. The drained meat is cured with "sake"-lees in a barrel for 20 days. The amount of "sake"-lees added is equal to weight of the salt-meat. Besides abalone, other big shell fish meats are also cured with "sake"-lees.

5. **Pickled products** ("Su-zuke")

Vinegar-pickled products are prepared at home. In Japan octopus and squid are vinegared or pickled as commercial products.

a) Pickled octopus and squid meat

The tentacles of octopus are separated from the body and the visceral mass is removed. The tentacles are cut into 2 to 4 blocks. The body and tentacle blocks are boiled in fresh water for 30 minutes. Then they are cooled rapidly. The cooled meat is cut into small pieces which are pickled in a barrel with a mixture of acetic acid (500 g), water (10 ~ 12 kg) and salt (500 g) per 50 kg weight of octopus meat. Pickled squid meat is prepared by the almost the same method.

b) Pickled fish meat

Small sea-bream, mullet, mackerel and sardines are pickled but are not important commercial products.

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JAPANESE STYLE FISH MEAT PASTES

I. The Japanese Style Fish Paste ("Kamaboko") Industry

From ancient times, in Japan, unique styles of fish meat paste have been processed. Their origin is not entirely unknown ; according to the old literature the Japanese style fish meat paste is said to have been processed in the 15 th century. The first Japanese fish meat paste was "chikuwa" which is ground fish meat paste coated around a a bamboo stick to a considerable thickness (about 3 cm) and heated. If the bamboo is pulled out after the processing, the fish meat paste forms a pipe-shaped round rod. The name "chikuwa" remains and the form has been kept up to the present time. Next, the fish meat paste piled up on a thin rectangular wooden plate appeared. This has been called "kamaboko". Afterwards, "hanpen" and "sumaki" appeared : "hanpen" is small disc-shaped fish meat paste (about 100 g) with a small straw blind of which the length is about 10 cm, and the diameter 0.3 cm. The present Japanese style fish meat paste thus originated from ground fish meat which was formed into various shapes and heated. At present, the fish meat is ground and shaped in various forms and is heated by various methods such as boiling in water, steaming, or a combination of steaming and broiling or frying. Recently fish sausage or ham have been processed and which are also considered to be a kind of fish meat paste.

The total amount of Japanese style fish meat pastes produced ("kamaboko", "chikuwa" and others) was 837,625 tons in 1968. One may be surprised by the large amount of Japanese style fish meat paste as compared with that of fish sausage and ham. The production of the latter was 1,214 million pieces (130 g per piece) of fish sausage (161,753 tons in 1968. This large production of Japanese style fish meat pastes reflects the conservative eating habits in Japan. The production1) of Japanese style fish pastes from 1964 to 1968 is shown in Table 8-1.

Table 8-1. Production of Japanese style fish meat paste and fish sausage (tons)

Year	Total	"Chikuwa"	"Kamaboko"	Fried "kamaboko"	Fish sausage and ham	Others
1964	734,639	119,455	219,874	205,129	175,864	14,314
1965	797,178	121,774	245,116	234,004	188,094	8,188
1966	895,136	157,636	270,214	286,616	176,026	7,642
1967	911,887	171,745	294,782	267,549	164,431	13,378
1968	999,378	194,035	336,365	289,501	161,753	17,722

Almost all producers of Japanese style fish pastes are small enterprises, except for several large manufacturers. The small producers keep their secrets for preparation of Japanese style fish paste, especially the makers of superior quality "kamaboko". The total number of licensed makers was 4, 404 in 1968. Before world war II, there were some large manufacturers of "chikuwa" in whose plants automation was employed. However, the advent of fish sausage has decreased the number of such "chikuwa" makers.

II. Kinds of Japanese Style Fish Paste

At present, after long year during which many changes of shape and heating have been tried out, there many shapes of Japanese style fish pastes prepared by various methods. The various kinds of Japanese style fish meat pastes are as follows : Steamed articles : "mushi-kamaboko", "sumaki", etc ; broiled articles : "yaki-kamaboko", "yakichikuwa", "konoha-kamaboko" (leaf-shaped "kamaboko"), "datemaki", "atsu-yaki", etc : boiled articles : "satsuma-age", "age-kamaboko", etc. Fish sausage and ham will be discussed in detail in a later chapter.

While there are many sorts of "fish paste" food products, Japanese style fish meat pastes are summarily defined as follows : fish meat paste is prepared from ground fish meat as a principal raw material, accompanied with seasoning materials (sugar, salt, sodium glutamate) and thickening materials such as starches. The ground fish meat is heated by steaming, broiling on a charcoal fire, boiling in hot water, or frying in deep fat.

III. Processing of Japanese Style Fish Paste

The several procedures followed in the preparation of Japanese style fish pastes may be described as follows. Raw fish, of which the kinds will be noted, are beheaded and eviscerated. After washing, the fish is separated from the bones and skin by means of a "meat separating machine" ("gyoniku-saishuki"). The fish are placed in the machine and pressed by means of plunger. Under pressure the meat is separated from the bones and skin and is forced through a perforated iron disc. The bones and skin remain behind. The flesh is soaked in a water tank. By the soaking, fat, blood and fish odor substances and small particles are removed. The bleached fish meat is dehydrated by pressing with a hydraulic press, or by means of a "centrifugal dehydrator".

Table 8-2. Scheme showing the preparation of Japanese style fish meat pastes

Preparing procedure	Raw fish		
	filletting		
	fleshing	←	by "fish meat collector"
	bleaching	←	in water
	dehydrating	←	by "cenrifugal dehydrator"
↓			
Grinding procedure	crushing	←	by "chopper"
	grinding	←	in a "stone grinder"
	mixing with complemental materials	←	in a "stone grinder"
↓			
Shaping procedure			
↓			
Heating procedure	steaming	→	"mushi-kamaboko"
	broiling	→	"yaki-kamaboko", "yaki-chikuwa"
	boiling	→	"hanpen"
	frying	→	"satsuma-age"
↓			
Finished goods (Japanese style fish pastes)			

The dehydrated fish meat is crushed with a "chopper" followed by grinding homogeneously in a "stone grinder", into which seasoning materials such as sugar, salt, sodium glutamate and complemental material such as starch are added. After grinding, the fish meat which has become adhesive is formed into various pieces. The pieces of shaped fish paste are heated. These procedures are classified into four stages: preparing, grinding, shaping and heating. In the initial procedures before the heating, there is but little difference between the various types of Japanese fish meat pastes, except for variation in the added supplemental materials.

IV. Principle of the Preparation of Japanese Style Fish Meat Paste ("Kamaboko")

Before going further, the principle of the preparation of Japanese style fish meat pastes will be explained. When salt is added to raw fish meat during grinding, myosins (actomyosin, myosin and actin) which are soluble in salt solution, are dissoved out from the fish meat to form a "sol", which is very adhesive. When this adhesive raw ground fish meat is heated, the "sol" convertes to "gel" forming a ternary network construction, this gel imparts elasticity to the fish meat paste. Fish meat coagulated by heating is the fish meat paste ("kamaboko"). The elasticity is called "ashi" in Japanese. When the elasticity is strong, the meat is said to have strong "ashi". In Japanese style fish meat paste ("kamaboko"), a high degree of elasticity is an important attribute.

Even if the raw ground meat has high adhesiveness, the fish paste product ("kamaboko") does not necessarily possess strong "ashi". This may be due to the fact that for some reason the strong ternary network construction may not have been formed. The strength of "ashi" differs according to the kinds of fish, and it is influenced by various factors. When NaCl is added to raw ground fish meat to dissolve out myosins, and it is left at room temperature without heating, the raw fish meat sometimes becomes jelly having elasticity but losing adhesiveness. Such a phenomenon is called "suwari" (setting). The phenomenon of "suwari" is caused intrinsically by the formation of network construction as well as by the phenomenon of "ashi". According to the species of fish, thus "suwari" occurs rapidly or slowly or sometimes does not occur at all(2).

According to Okada(3), the network construction may be made from the conjugation of protein molecules which are bound by bridges such as like salts, or bridges between carbonyl and imino radicals in peptides, by hydrogen and or by disulfide radicals formed from sulfhydryl radicals. When the fish meat paste having acquired elasticity as a result of the heating is left at room temperature for a long time, the elasticity is lost and the meat becomes fragile. Such a phenomenon is called "modori" (returning). This phenomenon, "modori", is also seen in ground fish meat which was heated slowly at a low temperature. Even if the ground fish meat, from which "suwari" has been occurred, is ground again, it does not become adhesive again. But if raw ground fish meat having weak "ashi" and which has already developed "suwari", is immediately heated, the "ashi" becomes strong.

The phenomena of changes in the elasticity can be explained by the dispersion of protein molecules. Simidu(4) has explained the phenomena

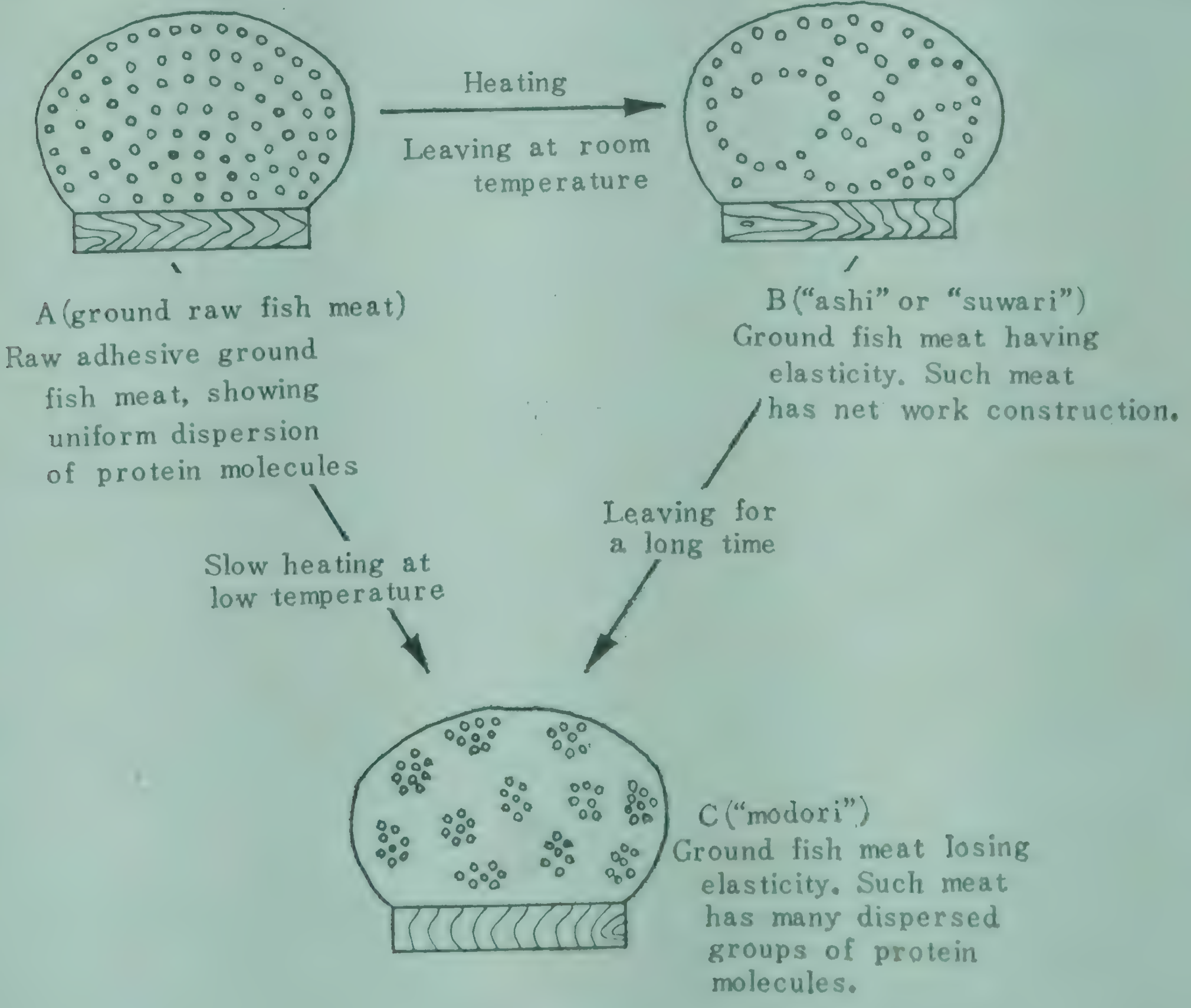
Heating
Leaving at room temperature
A (ground raw fish meat)
Raw adhesive ground fish meat, showing uniform dispersion of protein molecules
B ("ashi" or "suwari")
Ground fish meat having elasticity. Such meat has net work construction.
Slow heating at low temperature
Leaving for a long time
C ("modori")
Ground fish meat losing elasticity. Such meat has many dispersed groups of protein molecules.

Fig. 8-1. Scheme showing the relation between "ashi", "suwari" and "modori"

by means of the scheme shown in Fig. 8-1. As seen in Fig. 8-1, when raw adhesive ground fish meat shown as A in the Figure, A, heated or left without heating, the meat acquires elasticity, shown as B in the Figure. Such a meat has the network construction of protein molecules, in which water molecules are contained. When the ground fish meat heated or without heating is left at room temperature for a long time, it loses elasticity ("ashi") becoming fragile, shown as C in the Figure. Such meat has many dispersed aggregates of protein molecules, which are as if floating in water. In this case, protein molecules are easily isolated from water and the paste is as described above being fragile.

In order to strengthen the "ashi" of "kamaboko", starch is added to the ground fish meat. The added starch strengthens the "ashi" after the ground fish meat is heated at 80~85° C. When starch is added to the groumd fish meat and it is heated above 70° C, the contour of the starch particles is deformed by swelling. The strengthening of the "ashi" by adding starch is caused by this swelling. It has been thought that the swollen starch particles cause the protein molecules to adhere together. But according to Okada(5), when starch particles mixed with protein molecules swell due to heating, the strengthening of the "ashi" is caused at just that moment. In fact, according to his opinion, soluble starch such as dextrine or synthesized thickening materials such as CMC (carboxy methyl cellulose) can not strengthen "ashi".

The strength of elasticity ("ashi") and setting ("suwari") varies according to the species of fish. Okada(2) has made a table showing the relation between "ashi" and "suwari" according to the species of fish as shown in Table 8-3. Those differences are said to be due to the quantitative and qualitative properties of myosins in the fish meat.(6)(7)(8)(9)

V. Processing of "kamaboko"

Among the types of "kamaboko", steamed "kamaboko" is white in appearance, and it can not be preserved for a long time. This is mainly produced in the vicinity of Tokyo. Broiled "kamaboko" has dark brown color. This is mainly produced to the west of Osaka (west Japan). There many other styles of "kamaboko" produced in Japan,

Table 8-3. Relation between "ashi" and "suwari" (Okada[2])

	Fish meat easily developing "suwari"	Fish meat showing "suwari" moderate degree	Fish meat showing slight "suwari"
Fish meat having strong "ashi"	"eso" (lizard fish) "tobiuo" (flying fish "aji" (jack mackerel)	"guchi" (a kind of croaker) "hirame" (flat fish)	"same" (shark) "kurokawa-kajiki" (blue marlin)
Fish meat having medium "ashi"	"tachiuo" (cutlass fish) "kamasu"(baracuda, *Sphyraena pinguis*) "suketo-tara" (*Alaska pollack*)	"fugu" (globe fish) "nigisu" (*Argentina senufascuate*) "hamo" (strorp-toothed eel, *Muraenesox cinereus*)	"shiira" (dolphin fish, *Coryphaena hippurus*) "same-garei" (shark skin flounder, *Clidoderma asperrim*)
Fish meat having weak "ashi"	"ma-iwashi" (sardine, *Sardinia melanosticta*) "urume-iwashi" (round herring, *Etrummeus micropus*)	"sanma" (saury, *Coloabis saira*)	"katsuo" (bonito, *Katsuwonus pelamis*) "saba" (mackerel, *Scomber japonicus*) "kihada" (yellow-finned tuna, *Neothynnus macropter*)

e. g., "saiku-kamaboko" specially prepared "kamaboko".

1. Raw fish employed for preparation of "kamaboko"

White flesh fish are employed for the preparation of "kamaboko". For example, excellent raw materials are : "gisu" (sand borer, *Pterothrissus gissu*), "mutsu" (big-eye, *Scombrops boops*), "tai" (sea-bream, *Pagrosomus sp.*), "amadai" *Branchiostegus sp.*), "hamo" (strorp-toothed eel, *Muraenesox cinereus*), "eso" (lizard fish, *Saurida argyrophanes*), and cuttle fish (*Sepia esculenta*). The following fish are also employed : "guchi" (a species of croaker, *Nibea mitsukuri*), "tanago" (a species of minnow, *Acheilognattus morikae*), "kamasu" (*Sphyraena sp.*), pompanos ("aji", jack mackerel, *Trachurus japonicus*), cutlass fish ("tachiuo", *Trichiurus japonicus*), flying fish ("tobiuo", *Cypselurus agoo*), sea-robbin ("kanagashira", *Lepidotrigla strauchii*), wrasse ("bera", *Pseudolafrus japonicus*), flat fish ("karei", a species of flounder), sea-bass ("suzuki", *Lateolabrax japonicus*) and sharks ("yoshikiri same", blue shark, *Prionace glauca ;* "aosame", mackerel shark, *Isuropsis glauca ;* "hoshi-same", *Cynias manazo ;* "onaga-same", *Alopias vulpinus* ; and "mejiro-same", *Carcharkinus gangeticus*). Among them, "guchi" (a species of croaker), sharks and sand borer popularly used.

In the past, only fish having a delicious taste have been employed, but more recently, since the taste of the finished product can be improved by the addition of sodium glutamate, "ribotide" (sodium 5'-ribonucleotide), additional species of fish have come to be employed. Near Tokyo, use is made of white flesh fish meat having "ashi" after processing, but in to the west of Osaka fish meat having delicious taste is mainly used.

Recently, because of decreasing of the catch of the species described above, Atka mackerel ("hokke", *Pleurogrammus azonus*), and squid ("surume-ika", *Ommastrephes sloani pacificus* = *Todarodes pacificus*) are used for fish paste as the raw material. They are caught abundantly in waters around Hokkaido. However, there are faults in respect to color of the finished products in Atka mackerel, to "ashi" in Alaska pollack, and to skinning and taste or odor in squid meat. Tanikawa and Fujii(10) have studied the relative value of the flesh of these fish with a view to overcoming those faults. They obtained the following results :

(1) When each kind of fish is alone used as raw material for "kamaboko" products, the properties of the added amount of table salt in relation to the amount of each homogenized fish meat showning the largest "ashi" of finished product are for Atka mackerel 3 % and squid meat 2. 5 %, respectively.

(2) Observing the relation between the added amount of starch and the largest "ashi" of the finished products, it was found that 10 % is adequate for Atka mackerel and 20 % for squid, respectively.

(3) Observing the relation between the added amount of sugar and the largest "ashi" of the finished products, in the case of Atka mackerel meat, even if comparatively larger amount such as 12 % of sugar was added, the "ashi" of the finished products was not remarkably lowered.

(4) With decrease of the freshness of raw materials, the "ashi" of the finished product decreased. When the amount of volatile basic nitrogen in the fish meat over 20 mg %, the worth of the finished product lowered.

(5) Observing the change in the quality of the "kamaboko" stored at 0° C, with increase of the storing time, the "ashi" of the product decreases and it becomes fragile.

(6) Observing microscopically the structure of the "kamaboko" prepared from Atka mackerel without sugar, there are observed the microscopic net work construction of protein, starch, water, and oil etc.

(7) In order to strengthen the "ashi" of the finished product by squid meat, it is very effective to add Atka mackerel meat to squid meat. The limit proportion of the mixing of squid and Atka mackerel meat is 7 : 3. When the squid meat is used over the limit proportion, the elasticity is lowered. In this mixing, the additional amount of salt is to be good at 2 % for each meat of squid and Atka mackerel, respectively, the amount of starch to be 20 % for squid meat and 10 % for Atka mackerel.

When the homogenized squid meat of which the epidermis had been skinned by various treatments, and which had been pulped, is frozen and stored, the degree of the denaturation of meat protein is largest in the cases of autolyzing skinning or skinning by soaking in lactic acid solution. Those homogenized squid meat are not to be suitable as the raw material for "kamaboko". The homogenized squid meat treated by hand-skinning is satisfactory for a comparatively longer storing time, if the meat is rapidly frozen.

2. Preparation

The fish are washed, scales are removed if necessary, and the fish are beheaded and eviscerated. After washing and draining the fish are filleted. Small bones present in the abdominal side of the fish body are removed. In the case of sharks the meat is cut into pieces with a large knife. In a large scale operation, the separation of the meat from the fillet is carried out by means of a "gyoniku-saishuki" ("fish meat collector"). There are two types of "fish meat collector" : the disc type and the roll type.

The disc type has a round disc with small holes, on which fish fillets or beheaded fish bodies are pressed. The fish meat drops through the small holes into a fish meat box, which is placed under the disc. The horse power required is 1.5 Hp, r. p. m. is 300, and the capacity is 150 kg/hr. The roll type has a machine adapted to separate fish meat from fish fillets. The horse power required 1 Hp, r. p. m. is 160, and the capacity is 225 kg/hr.

In small scale factories the white flesh fish meat is separated by hand with a large knife from fish bodies. The fish meat thus obtained is used to prepare the fish meat paste which is applied as the final coating on the "kamaboko".

3. Crushing

In small scale factories, the separated large and small pieces of fish meat are cut up by hand with two large knives on a chopping table to crush the fish meat tissue. In large scale factories, an improved chopper or Ishikawa's "chopping roller" are used. A two-stage chopper can crush 190 kg per one hour.

4. Soaking

The finely cut fish meat is soaked in water for 24 hours to remove fat, blood, color and odorous substances. The water is changed two or three times during the soaking. The less fresh the fish meat is the longer the soaking time required. Ice blocks are added to the water tank, especially in summer. After soaking, the crushed fish meat is put into a cotton cloth bag and the bag is pressed with a lever or a hydraulic press. At present a "bulk centrifugal dehydrator" is also being used to de-water the fish. Dehydration or draining should be done to correct degree, not insufficiently and not excessively.

5. Grinding

The drained or dehydrated fish meat is ground in a stone grinder for 20～30 minutes to make it adhesive. This operation is called "kara-suri". Ishikawa's stone grinder has 3～4 pesties revolving in direction counter to that of the stone grinder. The capacity differs according to the size of the grinders. After the grinding, an appropriate amount of ground fish meat is spread flat on a dressing table and turned over repeatedly with a flat knife having a dull edge. During the spreading or turning, the remaining small bones and tendons are removed by hand from the ground fish meat. Next, the ground fish meat is ground again in a "stone grinder"; this time seasoning materials are added. The removal of bones and tendons is sometimes carried out by means of a "bone-separator".

6. Grinding with addition of seasoning materials

Japanese style fish pastes are made from one or more kinds of fish meat. The kinds of raw fish material for the fish meat paste, and their proportions differs according to the quality grade, places of production and seasons of the year. The ground fish meat from which bones and tendons are removed, is ground again as noted above after the addition of seasoning materials (salt, sodium glutamate, sodium 5′-ribonucleotide, sugar, sweet "sake") with some adhesive agent such as starch, polyphosphates or egg white. Salt is added first to the second grinding to increase the adhesiveness of the fish meat. If the salt is added in the final period of the grinding, the adhesiveness will be decreased. If the degree of adhesion is weak, starch is added. If the degree of adhesion is too strong, water is added. An example of the proportions of raw fish meat, seasoning materials and other materials is as follows : Ground fish meat —— 3.75 kg, salt —— 113～118 g, sodium glutamate —— 7.7～15g, sugar —— 170～552 g, starch —— 118～552 g, sweet "sake" —— 90 cc, egg white —— 8 eggs or polyphosphate 0.2～0.3 %, water —— adequate amount.

7. Shaping

For shaping, the seasoned ground fish meat is fixed by its own adhesiveness and piled upon a thin wooden plate. When piled on a plate in this manner it is called "itatsuki-kamaboko" (Fig. 8-2). The sizes of the thin wooden plates vary according to the area of production and the requests of the buyers. The sizes of the plates and the amounts of the piled ground fish paste are shown in Table 8-4.

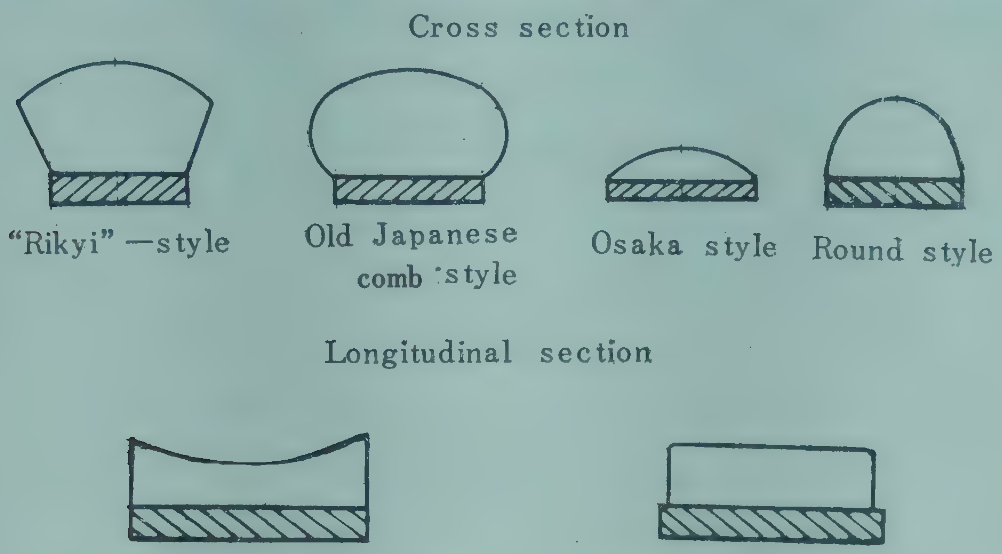

Fig. 8-2. Shapes of "itatsuki-kamaboko"

Table 8-4. Sizes of plates and amount of the piled fish paste

		Extra large	Large	Medium	Small
Sizes of wooden thin plate (cm)	Length	25	21	16	13
	Width	11	10	7	5.1
	Thickness	1.7	1.7	1.7	1.7
Weight of wooden plate (g)		169	121	73	49
Amount of the piled fish paste (g)		21, 513	1, 875	863	338

The piling of the ground fish paste on to the thin wooden plates is carried out by hand, or by machine, "kamaboko-itatsuke-ki". The wooden plates are made from pine (near Tokyo) or Japanese cedar (westward from Osaka).

Sometimes, the seasoned ground fish meat paste is shaped in rectangular form without fixation to a wooden plate; then the sizes are different according to the specifications of buyers. This fish meat paste is broiled on a heated iron plate, therefore it is called "kaku-yaki-kamaboko" (broiled rectangular "kamaboko").

8. **Heating**

a. Steaming

The fish meat paste fixed on wooden plates (raw fish paste) is placed in a steaming basket, which is steamed in the open air. The steaming time varies with the sizes of the wooden plates; large size is 80~90 minutes, medium size is 40~60 minutes, and small size is 20~30 minutes. The maximum temperature at the center of the fish paste reaches about 75° C, though that of the surface is 90~95° C. After the steaming, the fish meat paste ("kamaboko") is soaked in water for about 10 minutes in order to make the color brilliant white.

Steamed "kamaboko" is finished at this point.

b. Broiling

In stead of steaming, broiling is employed in the preparation of broiled "kamaboko" which is called "yaki-kamaboko". Broiled "kamaboko" before the heating is prepared in the same way as the steamed "kamaboko". Ground fish meat, to which sweet "sake" is added as one of the seasoning materials, is broiled on a charcoal fire to a dark brown color. If the sweet "sake" was not added to the ground fish meat before the broiling, a mixture of sweet "sake" and water is rubbed on the surface of the seasoned ground fish meat piled on a wooden plate. The sweet "sake" makes the surface a brilliant dark brown. When the fish meat paste is broiled on charcoal fire, the surface skin (coagulated protein at the surface of the fish paste) is caused to swell by the expansion of the air. In order to allow escape of the air under the surface skin, the broiling fish paste is pricked with a needle.

Sometimes steamed "kamaboko" is broiled after sweet "sake" is rubbed on its surface. This processing is simpler than that for the preparation of the broiled "kamaboko". Sometimes, when the fish meat paste fixed on its wooden plate is broiled, the charcoal fire is covered with ash to prevent the generation of fire flame, in order to accomplish broiling without burning. This "kamaboko" is called "shirayaki-kamaboko" (white "kamaboko" broiled). The raw fish material is "eso" (lizard fish) or other white flesh fish. The ground seasoned fish meat to which is added the white of 8 eggs, is shaped up on a wooden plate similarly to the other finished products.

c. Electric heating

In stead of steaming, electric heating is sometimes employed. The "kamaboko" heated electrically is called "denki-yaki-kamaboko" ("electrically broiled kamaboko"). The seasoned ground fish meat is placed in a cylindrical container, of which both ends (these are electrodes) are charged with electricity. The fish meat is heated by induction heating for 10~15 minutes. When the heating is completed, the electricity is switched off automatically. After the heating is over, the broiled "kamaboko" is ejected automatically from the instrument. This device for the rapid heating.

VI. Processing of "Chikuwa"

In ancient times, "chikuwa" was a preparation of seasoned ground fish meat rubbed thickly around a bamboo stick. The "chikuwa" was sold with the bamboo. However, at present, instead of bamboo sticks, pieces of brass pipe (dia. about 1.2 cm) are employed, and after the processing the brass pipes are pulled out. The procedures for the preparation of "chikuwa" are almost the same as those for "kamaboko" before the shaping.

1. **Raw materials**

As raw materials inexpensive fish are used such as shark, Atka mackerel (*Pleurogrammus azonus*), "suketo-tara" (Alaska pollack), cod, "kinkin" (a species of rockfish, *Sebastolobus macrochir*) and flat fish. Among them, shark and Atka mackerel are used as the principal materials. Cod and Alaska pollack are used as complementary raw materials. When shark meat is used, the ratio (percentage) is above 30 % of the total, while the other complemental raw materials are used to the amount of less than 70 %. On the other hand, when Atka mackerel is used, to above 60 % and the other complemental raw materials are below 40 %.

2. Dressing

After the fish are filleted the meat is separated with a "gyoniku-saishuki" (fish meat separator). Sharks are skinned first, and then the bodies are filleted. Generally the separation by the "fish meat separator" is carried out twice in order to increase the yield.

3. Soaking

The collected fish meat is soaked in water for about 24 hours in order to remove fat. During this time the water is frequently changed.

4. De-watering

After removing the fish meat from soaking water it is de-watered with a bulk centrifugal dehydrator.

5. Crushing

The de-watered meat is crushed with a two-stage chopper. The diameter of holes of the circular plate in the first chopper is 5 mm, and that in the second chopper is 3 mm.

6. Grinding

Only the crushed fish meat is put at first into a "stone grinder" and is ground for 20～30 minutes (this operation is called "karasuri"). At this "karasuri", fish meat having weak "ashi" (e. g., cod or Alaska pollack) is first put into the stone grinder, and then, after the adhesiveness of that meat has increased, the fish meat having strong "ashi" is put into it. During grinding, water is added to the meat to increase its volume. After the "karasuri" process, seasoning materials (salt, sugar, sweet "sake", sodium glutamate) and complemental materials such as starch are added into the "stone grinder". An example of the proportion of these materials is as follows: Crushed fish meat 52. 5 kg, starch 5. 6 kg, salt 1. 12 kg, sugar 150 g, sweet "sake" 360 cc. During the grinding, ice is added to the "stone grinder" in an amount judged to be sufficient to provide the desired amount of added water. If too much water is added difficulty is encountered in shaping the meat.

7. Shaping

In the past, the molding of the ground fish meat around a piece of brass pipe has always been done by hand. At the present it is done by a "chikuwa-keiseiki" ("chikuwa" making machine).

In Kawaguchi's-type of "chikuwa"-making machine, the ground fish meat pushed from a hopper is molded as a cylinder around a revolving brass pipe. The molded pipes are conveyed onto a long charcoal fire furnace. The amount of fish meat paste around a brass pipe may differ according to the manufacturer and the quality grades. For example for the first class grade, 113～120 g of seasoned raw ground fish meat is shaped up around the pipe. After the broiling the weight becomes 105～112g. With the second grade, 102～105 g of the sesoned raw ground fish meat is broiled to the weight of 95～97 g. Generally the length of the finished merchandise ("chikuwa") is 19 cm, the outside diameter is 3 cm, the inside dimeter of the pipe is 1 cm, and the weight is 112～117 g.

8. Broiling

In the past, the ground fish meat molded around bamboo sticks was broiled by being turned constantly by hand over a charcoal fire brazier for 4～5 minutes.

At present, the ground fish meat molded around pieces of brass pipe is rotated while being conveyed through a long furnace (15～18 meter). En route to the furnace, the ground fish meat is adequately drained. By passing over the long furnace for 4～5 minutes, the fish meat is broiled. The long furnace consists of three sections; initial, central and final sections, in which the intensities of the fires are different. In the initial section (about 6 meter) the ground fish meat is broiled over a medium fire, in the central section over very strong fire, and in the final section over a weak fire. If the ground fish meat is adequately drained and the fire is strong, the surface of the ground fish meat is broiled to dark brown and the surface becomes swollen. The color of the surface of the broiled fish paste is varied according to the demand of a particular market. Near Osaka the dark brown is liked, on the contrary, near Tokyo the light brown is liked.

9. Removing sticks

When the broiling of the ground fish paste is completed, the brass sticks are removed with a "kushinuki-ki" ("pulling out machine"). The brass sticks are then re-used after having been properly cleaned.

10. Packaging

The finished merchandise (this is called "chikuwa") is wrapped with parchment or paraffin paper and packed in wooden cases or cartons. One case contains 234 pieces of "chikuwa", of which the net content weight is 25. 3 kg.

VII. Processing of "Hanpen"

"Hanpen" is a product made of ground fish meat which was boiled in hot water. Raw materials for superior quality are sharks ("ao-same", mackerel shark; "onaga-same", thresher shark; "mejiro-same", white eye shark, (*Carcharinus japonicus*); In the summer marlin meat is added to shark meat to the extent of about 1/3 of the shark meat. For common quality goods, mackerel shark and "yoshikiri-same" (great blue shark) meat is employed.

The processing is almost the same as that for "kamaboko" up to the point of heating. One difference in the preparation between "hanpen" and "kamaboko", is that crushed yam and rice flour are added to the ground fish meat in the preparation of the former. After grinding the crushed fish meat ("karasuri"), one-third of the ground material is taken out from the "stone grinder". To the two-thirds of the ground fish meat (11. 3 kg) remaining in the stone grinder, 750 g of salt, 600 g of crushed yam, 150 of rice flour and 900~980 cc of sweet "sake" are added. After the grinding has been continued for several minutes, the ground fish meat previously removed and 1 1/2 tea cups of starch (100~150 g) are added to the 11. 3 kg of material, and grinding is continued. The seasoned ground fish meat is put in a small wooden pattern mold of circular or square shape. When the mold is soaked in water the shaped ground fish meat can be removed. The shaped ground fish meat is then transferred into hot water at 85° C. When the fish meat is heated for about 7 minutes, it will float on the surface of the water. The heated ground fish meat having been shaped (this finished cake is called "hanpen") is cooled on cotton cloth in a box.

"Hanpen" is of rectangular size and about 6 to 8 cm square. The weight of a 6 cm square "hanpen" is about 300 g.

VIII. Processing of "Satsuma-age"

"Satsuma-age" was prepared first at Kagoshima Prefecture (Old name, Satsuma), according to its name. "Satsuma-age" is a product made of ground fish meat prepared by the same procedures as "kamaboko" and then fried in deep fat.

As raw material, lizard fish ("eso"), mackerel shark ("aosame") and great blue shark ("yoshikiri-same") are employed. The proportion is 6 parts of shark meat to 4 parts of "eso" meat. Sardine meat is sometimes added to inexpensive "Satsuma-age". When the ground fish meat is completely prepared, fine cut carrot and seasoning materials are added. An example of the proportions of ingredients is as follows: ground fish meat 37. 5 kg, sugar 3～3. 75 kg, salt 750～940 g, starch 29. 4 kg, carrot 11. 2 kg, sweet "sake" 360 cc. Those materials are mixed in a "stone grinder", and then formed into small 50 g pieces of various shapes, flat square, circular, rectangular or triangular respectively. Near Osaka, besides carrot, fine chopped onion or burdock and green peas are added to the ground fish meat. The shaped ground fish pieces are fried in boiling oil (gingerly-oil or rape-oil). When the ground fish meat is heated sufficiently, it will float on the surface of the oil. More recently the shaping has been done with a "Satsuma-age-making machine".

IX. "Naruto-maki" (or "Sumaki")

The raw materials and the processing are almost the same as in the making of "kamaboko". The preparation is as follows: Ground fish meat prepared like that for "kamaboko" is spread as a sheet with a flat knife having a dull edge. Onto the spread ground fish meat additional ground fish meat dyed with red or blue coloring material is piled and spread. From one end, the piled sheets of ground fish meat are rolled and the roll is covered with a bamboo blind. The rolled fish meat is steamed. This product is called "naruto-maki", which is a kind of special prepared "kamaboko".

Another rolled fish paste, to which egg yolk is added, is called "date-maki" ; it is larger than "naruto-maki". The color of "date-maki" is yellow.

X. Processing of Fish Meat Balls

This is not a Japanese style fish paste. To the ground fish meat mashed potato is added with homogeneous mixture : The mixture is shaped into small balls which are fried in deep fat in the same way as "Satsuma-age".

XI. Factors influencing "Ashi" of Japanese Style Fish Paste

The elasticity ("ashi") of processed Japanese style fish meat pastes is important in the estimation of their quality grade, as mentioned above.

The strength of "ashi" has been estimated by various methods(11)(12)(13)(14)(15)(16) according to the investigators. For example, squeezing with a plunger, cutting with a knife, picking up by hand, or pulling methods have been applied. Matsumoto(14) has made a gelometer as shown in Fig. 8-3. Matsumoto has divided the strength of "ashi" into two forms : the depression strength and breaking strength ; the former is revealed by the load on the plunger when it sinks down a definite length (5 mm), balancing with the deformation of the sample ; and the breaking strength is shown by load at the instant when the plunger descends rapidly penetrating the sample.

Simidu's apparatus(17) for estimation of "ashi" by a pulling method will be briefly described. A sample of the fish paste ("kamaboko") is cut as shown in Fig. 8-4. The ends of the sample are pulled at a velocity of 0. 3 cm/sec. by a motor until it breaks. Elongation and

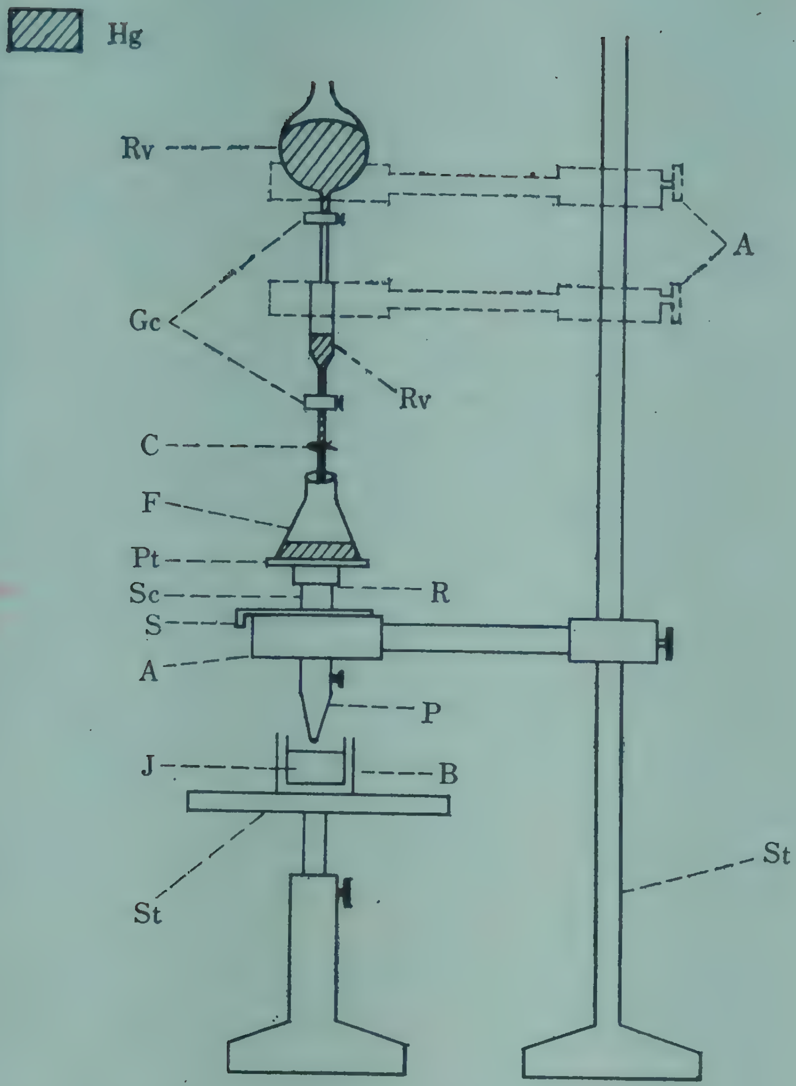

Fig. 8-3. Matsumoto's gelometer
A : arm, B : beaker, C : cock, F : flask, Gc : glass cock, Hg : mercury used as weight, J : fish past sample (jelly), P : plunger Pt : plate, R : rod, Rv : reservoir, S : stopper, Sc : scales, St : stand

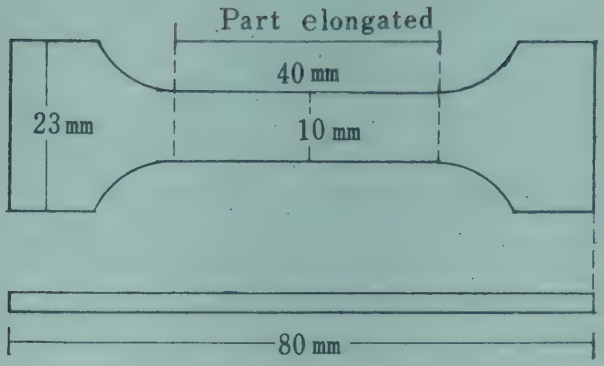

Fig. 8-4. Size and shape of a sample

tensile strength required to break as a result of the pulling are estimated with the apparatus. Shimizu et al.(18) have defined the product of the tensile strength of "ashi" (tensile strength × elongation = "gel strength" = "ashi").

The formation of "ashi" is due to the qualitative and quantitative properties of myosins in fish meat(6)(7)(8). Therefore, the strengh of "ashi" depends on the properties of fish meat (dependent upon fishing places and freshness), the proportion of complemental materials (salt, sugar, starch) and condition (difference between fresh and frozen fish, soaking, pH of the ground fish meat, heating temperature or time).

1. Relation between the kinds of fish and "ashi"

From ancient times, the famous trade article "kamaboko" has been prepared from fish meat having strong "ashi". For example, sand borer ("oki-gisu", *Pterothrissus gissu*) at Odawara (near Tokyo) ; flat fish ("hirame" a species of flounder, *Paralichthys olivaceus*) at Sendai : flying fish (*Cypselurus agoo*) at Toyama (Japan Sea) ; lizard fish ("eso") at Sensaki (Yamaguchi Prefecture) and Uwajima (Shikoku district) ; big-eye ("mutsu") at Kushimoto (Wakayama Prefecture) ; and spotted shark (*Cynias manazo*) at Kagoshima. The raw meat of these fish has strong "ashi". Besides these fish, many other spieces of fish described previously in raw materials of "kamaboko" are also employed because of their strong "ashi".

The protein concerned with "ashi" of "kamaboko" is considered to be myosins(7)(8)(9), for example, according to Kitabayashi(7), the amount of myosins in the meat of flounder is three to four times that in squid meat, consequently the "ashi" of the former is strong while that of the latter is weak. If the raw fish meat for preparing "kamaboko", of which the protein molecules form a network construction, contains much fat, the ring structure in the "kamaboko" breaks, because of standing fat particles between the protein molecules, and the "ashi" is lost. The fact that the "ashi" of "kamaboko" prepared from fish meat containing much fat is weak, e. g., sardine, saury, mackerel, bonito, tuna etc., may be explained by the suggestion noted above. Fish meat having much fat, even if they are white flesh fish such as oily shark, jack mackerel, rose rock fish ("menuke", *Sebastodes baramenke*), "abura-karei" (a species of flounder, *Reinhardtius metenurae*), Atka mackerel, are employed to prepare "kamaboko", the "ashi" of which is sometimes weak. However, fat content in fish meat is not necessarily proportionate to the strength of "ashi" of processed "kamaboko". For example, if "gisu" or blue marlin having large amount of myosins are employed to prepare "kamaboko", the "ashi" is strong. This is explained by the stronger influence of myosins than that fat. However, generally speaking, the "ashi" of "kamaboko" processed from fish meat having much fat, is weak. Therefore in order to strengthen the "ashi", during the preparation of "kamaboko" fatty tissue must be removed and bleaching must be carried out by soaking the fish meat in water.

2. Relation between fishing season or place and "ashi"

Fish meats of which the taste is at its seasonal best are probably considered to be the best raw material to be employed. However, on the other hand, such fish meat has generally much fat. The season of best taste is called "shun" in Japan. In fact it is the spawning season of the fish. Somewhat paradoxically meat of fish which are caught during this season should be avoided for the preparation of "kamaboko", because of the weakness of its "ashi". White flesh fish meat having strong "ashi", even thought the fat content may increase more or less from season to season, should be employed for the preparation of "kamaboko", because the taste of the product is better and there is no fear of losing the "ashi". At any rate, constant attention must be given to the matter of "ashi" of raw fish. As to fishing areas, the fish caught in the northern sea has a high fat content. In the case of the same district the fish caught in places nearer to the coast contain much more fat than that caught at a distance from the coast line. At any rate, those fish meats having a comparatively lower fat content are better for the preparation of "kamaboko".

3. Relation between the freshness of fish meat and "ashi"

As the freshness of fish meat declines, the weaker is the "ashi" of the processed "kamaboko". This may be due to the denaturation of fish meat protein which decreases its solubility. In fact, "eso" (lizard fish) meat has strong "ashi" while it is fresh and accordingly from ancient times it has been employed to prepare good quality "kamaboko"; but when its freshness falls, the "ashi" rapidly becomes weak. Alaska pollack is also one of the typical examples, which becomes weak within several hours after being caught. As exceptions, the "ashi" of "guchi" (a species of croaker, *Nibea mitsukuri*) or shark is not weakened even after a loss of freshness. Especially as to shark meat, the older the meat becomes, the stronger is the "ashi" of "kamaboko" processed therefrom.

4. Relation between the pH value of fish meat and "ashi"

The "ashi" is also influenced by pH value of raw fish meat. According to Shimizu et al.(18), the "ashi" of "kamaboko" is strongest when it is prepared from the fish meat of pH 6. 5~7. 0.

In alkaline side, "ashi" becomes weak. The reason why the "ashi" is influenced by the pH may be that the solubility of the fish meat protein is small on the acidic side, but it becomes larger near the neutral point, therefore the myosins dissolve more easily at pH 6. 5~7. 0. Generally speaking, besides the solubility, the swelling, hydration of the proteins of fish meat are minimum at the isoelectric point which for fish meat protein is pH 5~6(20)(21)(22), and that of myosins is pH 5. 1~5. 4(23). Therefore on the acidic side from or the alkaline side from the range of pH 6. 5~7. 0 of raw materials, becomes weak after being processed.

Further study was carried out by Miyake and Tanaka(24) on relation between pH of fish meat paste and "ashi" of "kamaboko", using mackerel (*Scomber japonicus*), bluefin tuna (*Thunnus thynnus*) and yellow tail (*Seriola guingulradiata*) as dark-fleshed fish group, and "isaki" (*Parapristipoma trilineatum*), flat fish (*Kareius bicoloratus*), frozen meat paste of Alaska pollack (*Theragra chlalcogramma*), and Japanese seabass (*Lateolabrax japonicus*) as white-flesh fish group. The results indicated that the optimum pH's of meat pastes of dark and white-fleshed fishes (for the formation of "ashi") were 6. 2~6. 7 and 7. 0~7. 5, respectively, and that of horse mackerel was 7. 0~7. 2. Miyake and Kawakami(25) have also investigated the effect of amino acids on the "ashi" of "kamaboko", and have found that basic amino acids at 0. 2~0. 5 % concentration in fish meat paste is effective to strengthen the "ashi", at that time pH range is 7. 5~8. 1.

5. Relation between freezing of fish meat and "ashi"

It is best to use raw fish for the preparation of "kamaboko". However frozen fish are sometimes used, because the distances to the fishing areas have recently been extended. During freezing, the proteins of fish meat will denaturate. The "ashi" will become weak as described above.

6. Relation between the amount of salt added to raw ground fish meat and "ashi"

The addition of salt to the raw fish paste is important not only for seasoning, but also for dissolving out myosins in order to form "ashi".

Tanikawa et al.(10) have studied the relation between the amount of salt and strength of "ashi". According to their observations, if the amount of added salt is 3 % of the weight of the seasoned ground fish meat (containing starch), the "ashi" was the strongest. As the seasoned ground fish meat had 85 % of moisture content, if to the fish meat is added 3 % of salt, the salt concentration will become about 3. 5 %, corresponding to 0. 6 mole, which can dissolve out an optimum amount of myosins from the raw fish meat. Therefore, the amount of added salt should generally be about 3 %.

7. Relation between the amount of starch added to the raw ground fish meat and "ashi"

Except in "kamaboko" of the superior quality grade, starch is generally added to the ground fish meat in order to supplement the "ashi", especially to fish meat having weak "ashi". When starch is added, the processed "kamaboko" becomes too firm (this hardness has no elasticity which is shown as "ashi"), therefore water must also be added. According to Tanikawa et al.(10), if water is not added, the maximum amount of added starch should be within 10 %, but the processed "kamaboko" becomes firm and fragile. If 5 %, of water is added, the amount of starch can be increased to 20 %. This may be due to the fact that in the constituents of the "kamaboko" (fish meat protein — water — salt system) the degree of dispersion of starch molecules may be changed according to the amount of water added. Of course, the relationship in the system will be differ with the kinds of raw fish meat and the kind of starch employed.

This fact was also found by Ikeuchi,(20) who investigated enhancing effects of various "ashi"-forming substances on "kamaboko". He compared "ashi"-foming ability of various substances such as polyvinyl alcohol, methyl cellulose, carboxymethyl cellulose, gelatin, gluten and starch. The results showed that the addition of viscous by hydrocolloids such as polyvinyl alcohol, carboxymethyl cellulose, methyl cellulose and gelatin rather reduced the "ashi" of "kamaboko", and that the addition of starch to the brayed meat affording a weak "ashi" increased the strength for from than gluten. It was inferred that substances used to enhance "kamaboko" had to be dispersed uniformly in a state of grain into brayed meat in beginning, and that such substances had to bind a great amount of water and form irreversible rigid gels in a comparatively low concentration.

8. Relation between the amount of sugar added and "ashi"

Cane sugar is generally added to the ground fish meat (raw fish paste) in order to season and to import a brilliant appearance to the surface of the finished "kamaboko" product. Especially in large cities the amount of sugar added to "kamaboko" may reach 10 %.

9. Relation between amount of oil added to the ground fish meat and "ashi"

As above stated, fish meat having a high fat content according to the kinds and seasons is unfit for preparation of "kamaboko". However, only recently in order to enrich the nutritive value of "kamaboko", the addition of oil to the ground fish meat has been tried with steps taken to counter-balance the decrease of "ashi". If the amount of water and starch are correct, the "ashi" of processed "kamaboko" is not significantly decreased, even though the amount of oil added was relatively large.

10. Relatin between the addition of polyphosphates and "ashi"

In the meat products industry in Europe and the U. S. A. the use of polyphosphates has increased in order to increase the adhesive effect and the elasticity. In Japan, their use has been permitted since 1957 and accordingly many studies concerning polyphosphates in food technology have been carried on. The effects of polyphsophates on the hydration and adhesiveness of meats are considered to be due to a rise in pH value and ion strength of the meat, to their functions to dissolve myosins out easily; to prevent the contraction of meat muscle by chelating Ca^{++} or Mg^{++} ion with polyphosphates; and to swell the meat protein. Furthermore such polyphosphates as pyrophosphate, tri-polyphosphate or hexametaphosphate decompose actomyosin as does adenosintriphosphate. The amount of myosin will increase in the meat and accordingly the solubility of the protein increases to enhance hydration (27)(28). At any rate it is certain that the polyphosphates exert a strengthen effect on the "ashi" of "kamaboko", though their effects are different according to single or combined use.

11. Relation between soaking of raw fish meat and the strength of "ashi"

As stated above, the soaking is customarily carried out in order to remove fat and blood so as to make the "ashi" of the processed "kamaboko" strong and to make the color white. From old times, dog fish ("abura-same", *Heptranchias perlo*), or a flounder species ("*Reinhardtius matenurae*) having a high fat content, have been soaked in water in order to strengthen "ashi". More recently, even if these fish are employed for "kamaboko" preparation the "ashi" of the product can be strengthened by the addition of polyphosphates. Therefore, if fish of high fat content are employed in "kamaboko" making, there is no need to soak if the preparation is carried on carefully and with the addition of polyphosphates. One of the reasons why the soaking is effective in strengthening "ashi" of "kamaboko" is that water-soluble proteins are removed and thus the relative concentration of myosins is increased.

12. Relation between the heating conditions and "ashi"

The "ashi" of the "kamaboko" is obtained by heating the raw fish meat. But the "ashi" formed is different according to the heating conditions. The "ashi" of the "kamaboko" processed at high temperature for a short time is stronger than that formed at low temperature for a long time.

13. Relation between the addition of oxidizing agent and "ashi"

According to Okada(3) the addition of oxidizing agents such as potassium bromate, which is used for improvement of the quality of wheat flour, has the effect of increasing the "ashi" of "kamaboko" prepared from fish meat naturally having a weak "ashi". However, the use of potassium bromate is not yet permitted by law in Japan and at present it is not employed during the preparation of "kamaboko".

XII. Spoilage of Japanese Style Fish Paste

1. Steamed "kamaboko"

As "kamaboko" is prepared by heating the ground fish meat, it can not be preserved for a very long time. That is to say, it is considered to be rather a perishable food. However, it can be preserved for 7~9 days in spring and autumn and 1~2 days in summer, though the preservation period differs according to the constituents of the marchandise, e. g., especially in relation of sugar or starch. The spoilage of "kamaboko" may differ according to its constituents. Kimata[30] has classified types of spoilage as follows :

Type I : Spoilage in which acidic transparent mucous water-like drops are formed on the surface of "kamaboko".

Type II : Spoilage in which butter or cheese-like opaque substances are formed on the surface of "kamaboko".

Type III : Spoilage in which molds grow on the surface of "kamaboko".

The different types of spoilage of "kamaboko" may be due to the kind and amounts of carbohydrates (sugar or starch) which were added to the material. Type I is called typical "neto", which is often seen in "kamaboko" to which sugar was added. The drops of liquid are acidic and do not smell of ammonia. This type of spoilage is caused by *Streptococcus*, *Leuconstoc* and *Micrococcus* species which from acids. Type II has often been found in "kamaboko" without added sugar. The mucous substance formed on the surface is alkaline and smells of ammonia. This type of putrefaction is caused by *Micrococcus*, *Serratia*, *Flavobacterium* and *Achromobacter* species which have proteolytic action. Type III spoilage begins with the growth of mold. This has been also often found in "kamaboko" with no added sugar. The difference between types II and III may be due to the amount of starch added. If the amount of starch is small, the "kamaboko" will spoil after type II ; and if the amount is large, it will be subjected to type III spoilage. The boundary line is 35 % starch on a moisture-free basis. However, if the humidity in the air is high, or if the surface of "kamaboko" is wet, type I spoilage will occur without regard to kind or amount of carbohydrate added. In this case, on the "kamaboko" with no added sugar, there occur drops of mucous which are neutral or alkaline and they gradually become opaque. When the surface of "kamaboko" without added starch or sugar is dried and left in the open air in the room, it will not spoil or become dry unless the humidity is rather low. However, when "kamaboko" with added starch is left in the room, it will spoil from the inside, although the appearance may be normal. Finally the "kamaboko" will be deformed.

The spoilage from outside in "kamaboko" is caused mainly by bacteria in the air, such as *Micrococcus*, *Serratia*. That from the inside is caued by *Bacilli*, which were contaminants of the added starch.

2. **Broiled "kamaboko" or "chikuwa"**

As to broiled "kamaboko" which has a dried skin formed as a result of coagulation of the surface fish meat by broiling, spoilage putrefaction from the outside rarely occurs, but that from the inside is often found. Broiled "kamaboko" with no added sugar and starch scarcely ever spoils. The "kamaboko" steamed after being broiled spoils as well as the steamed "kamaboko". This may be due to the fact that sterilization was accomplished by the steaming which was carried on after the broiling. Similarly the "kamaboko" broiled after steamed spoils as well as that which was broiled directly.

Broiled "chikuwa" does not spoil from the outside but will spoil on the inner surface of the hole formed when the brass pipe was removed.

3. **Fried fish paste** ("satsuma-age")

Fried fish paste, "satsuma-age", of which the surface becomes a skin formed by frying does not spoil from the outside, but only from the inside, especially, if starch and vegetables such as carrots or burdock have been added.

4. **Bacteria which survive after the processing of "kamaboko"**

"Kamaboko" products with added starch or sugar often spoils from the inside as noted above. This may be due to bacteria which were present in raw materials or added complemental materials and survived the heating. During the processing the temperature at the center of "kamaboko" is highest in the broiled "kamaboko", next in "satsuma-age" and is lowest in the steamed "kamaboko". If the steamed "kamaboko" (that is fixed onto large or medium wooden plates) is processed at 93° C, the temperature in the center reaches 65°~72° C. Yokoseki(31) has stated that when the temperature of the center of "kamaboko" was below 70° C, cocci were found; and above 70° C no anaerobic bacilli were found. If the temperature of the center of "kamaboko" with added starch is below 70° C, cocci were usually found, and above 70° C, spore-forming bacteria such as *Bac. megatherium*, *B. subtilis*, *B. coagulans* and *B. firmus* were found to survive.

If "kamaboko" is placed at room temperature for a couple of days, it will produce a transparent, slimy material called "neto" on its surface as if it were sweating. This "neto" is made of bacterial colonies. The bacteria which form "neto" are dominantly of various kinds, for example for sugared "kamaboko": *Streptococcus*, *Leuconostoc* and *Micrococcus*, and for non-sugared one: *Micrococcus*, *Serratia*, *Flavobacterium* and *Achromobacter*. Those bacteria will invade into the inner part of the "kamaboko" from the point of the "neto", and at last cause spoilage. Tanikawa and Fujii 32) have studied the invasion of the bacteria, the course of invasion and velocity of the invasion by microscopical photographic observations using non-sugared "kamaboko" which was made from Atka mackerel meat with by potato starch added.

The "neto" bacteria invaded the inner part of the "kamaboko" by moving from particle of starch in the "kamaboko". The part of fish meat protein in the product has initially scarcely been attached by the "neto" bacteria. The degree of the invasion of "neto" bacteria at 15°C was estimated to be about 50, 200, 600, 1,000, 1,800 μ in depth on the 1st, 2 nd, 3 rd, 4 th and 5 th day respectively after the formation of the "neto" on the surface of the "kamaboko".

5. Origin of spoilage bacteria in "kamaboko"

Then, from where did the thermotolerant bacteria in "kamaboko" come? Many investigators have stated that their origin is in potato starch. In fact, Kimata(33)(34) and Yokoseki(35) have isolated many bacteria from various kinds of starchs as shown in Tables 8-5, 8-6, and 8-7.

As seen in Table 8-5, in each g of these kinds of starch 10,000~50,000 thermotolerant bacteria were present, amongst which spore-forming bacteria accounted for 70 %.

Table 8-5. Thermotolerant bacteria (bacteria surviving 80°C for 10 minutes) in various kinds of starch (Kimata(29))

Kinds of starch	Sweet potato starch ("ukiko") (superior quality)			Sweet potato starch(common) ("nami")				Potato starch			Total
Grade / Kinds of bacteria	1	2	3	1	2	3	4	1	2	3	
Bac. subtilis	0	1	1	1	2	2	1	0	1	1	10
Bac. megatherium	6	7	5	5	10	6	8	4	7	1	57
Bac. cereus	0	0	1	0	0	1	0	2	2	1	10
Bac. cereus var. mycoides	1	0	0	3	0	0	0	3	0	4	7
Bac. circulans	2	2	2	1	0	2	2	2	2	0	17
Bac. laterosporus	0	1	3	0	0	2	0	1	0	2	9
Bac. brevis	0	0	0	0	0	0	0	0	1	2	1
Microc. caseolyticus	1	0	0	0	0	0	0	0	0	0	1
Microc. pyogenes var. albus	1	0	0	0	0	0	0	0	0	0	1

As seen in Table 8-6, in each g of those samples 1,100~1,900 bacteria were found of which 50 % were spor-formers.

Table 8-6. Number of spore-forming bacteria strains in wheat starch (Kimata(30))

Sample / Isolated species	Number of strains				
	A	B	C	D	Total
Bac. subtilis	12	6	12	12	42
Bac. pumilus	2	5	3	2	12
Bac. laterosporus	1	0	0	0	1
Bac. megatherium	0	0	4	2	6
Bac. cereus var. mycoides	0	0	0	2	2
Bac. cylindricus	0	0	1	1	2

Table 8-7. Number of strains of spore-forming bacteria in potato starch (Yokoseki(31))

Sample / Isolated species	Number of strains
Bac. mesentericus (*Bac. subtilis var.*)	32
Bac. lactis	4
Bac. paburi	1
Bac. sublustris	1

As seen in Table 8-7, in each of the sample, 53,000 bacteria were counted, of which 5,200 survived 80° C for 10 minutes. Those thermotolerant bacteria in starch are added to the ground fish meat in company with the starch, and even after the processing they survive and cause the inside spoilage.

In fish sausage, in which the ground fish is stuffed in a casing, the contamination from the outside is little or none. However, "kamaboko", especially steamed "kamaboko", is as whole exposed to the air, and accordingly spoilage from the outside occurs more often. At present time "kamaboko" is sometimes packaged with cellophane film in order to decrease the outside contamination.

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FISH SAUSAGE AND HAM INDUSTRY

I. Introduction

1. History

Large quantities of fish sausage and ham have been produced in Japan for the past several years. The production of fish sausage and ham totaled 161,753 tons in 1968. This weight corresponds to about 1,200 million pieces of fish sausage, if all the production were converted into 130 g pieces which is usual weight of portions as sold on the market. In Japan the fish sausage and ham industry is managed by big enterprises, especially by the large fishing companies. Large scale factories are units in big enterprises. Some factories have a scale of daily production of 750,000 pieces of fish sausage (at net weight of 130 g per piece).

Turning back to the past, studies on preparing fish sausage were carried on by some Prefectural Fisheries Experimental Station as long ago as 1925, but actual manufacturing was unsuccessful perhaps owing to the quality of the product, or having been before the times. In 1938 attempts were made by Dr. W. Simidu (Jap. Pat. 127846) to prepare a fish ham from tuna meat. However, it also did not become as popular as it is today. This was perhaps because the fishy odor in fish ham of those days could not be overcome, and the product was not compatible with the rice of the staple diet.

It is only within the past ten years that the fish sausage and ham industries have attained the important position they enjoy today. After World War II one of big fishing companies, "Nippon Suisan Co." (Japan Fishing Co.) promptly undertook to study manufacturing fish sausage and ham by utilizing whale meat from the Antarctic Ocean and catches of trawler ships in the East China Sea. From about 1953 the processing of fish sausage and ham has gradually become a mass production enterprise.

The key to the success of processing these products was the advent of "ryphan" sausage casing (rubber hydrochloride film casing) and the accumulated results of scientific studies on the processing of the Japanese fish paste ("Kamaboko") which has been eaten by Japanese from ancient times. On the other hand, there has been much publicity by several big fishing companies, which have carefully and completely planned each step in the manufacture. The fact that fish sausage and ham go well with bread eating which has increased in Japan since the war, also should not be neglected as one reason for the activity of the fish sausage and ham industry.

In 1954 the amount of production of fish sausage and ham were first reported in the "Annual Report of Catch Statistics of Fishery and Aquiculture by the Japanese Government, Ministry of Agriculture and Forestry". The total was 1, 995 tons. Since that time the production has increased year by year until 1965. The amount of production in 1965 was 188, 094 tons, and was the maximum. Production of fish sausage and ham in 1964～1968 is shown in Table 9-1. The number of licensed makers of fish sausage and ham was 79 in 1953, as compared with 4,800 producers of Japanese style fish paste("Kamaboko"). The small number of manufactures is attributed to the fact that the plants for the processing of fish sausage and ham are so expensive that they are restricted to well-capitalized fish companies, which can catch whale, tuna and other fish using their own ships.

Table 9-1. Production of fish sausage and ham in 1964～1968 (1, 000 tons)

Year	1964	1965	1966	1967	1968
Production (tons)	175	188	176	164	161

2. Preparation of fish sausage and ham

a. Brief processing of fish sausage

Fresh white flesh fish are dressed on a dressing table by removal of head, tail, visceral mass, and bones, then filleted, and finally skinned if the fish are of large size. The filleted fish are crushed through a chopper. The crushed fish meat is soaked in fresh water in order to remove fat, blood and extraneous substances, and to bleach. The bleached fish meat is drained with a "bulk centrifugal separator". In order to increase the redness of red flesh fish, potassium or sodium nitrite is added to the red flesh blocks, (according to Japanese Law, the residual amount of nitrite must be less than 70 mg per 1 kg of the finished products) by soaking in a salt solution containing potassium or sodium nitrite. The reddened fish meat is crushed through a chopper.

The pieces of bleached of reddened fish meat are ground with a "stone grinder"; during the grinding fine salt is added in order to make the fish meat adhesive; vegetable oil, sodium glutamate, "ribotide" (sodium-5'-ribonucleotide, Takeda Pharmaceutical Co. Ltd., Osaka), sugar, preservatives (sorbic acid and its sodium and potassium salts, furylfuramide), spices and condiments, and coloring materials are also added to the ground meat. During the grinding, powdered starch is added to adjust the elasticity (this is called "ashi") of the finished products, and then the grinding is stopped. Raw pork fat cut into dice-sized pieces is mixed with 7～10% by weight of the ground fish meat in a mixer.

The ingredients are stuffed into one of the several types of sausage casings which will be discussed later. The mouth of the casing is sealed with a "sealing machine". The sealed fish sausage are processed at 85°～87°C for 60 minutes in continuous cookers. After processing, the sausage are cooled in a continuous cooler, during that time the surface of the fish sausage casings become wrinkled. The cooled sausages are soaked in boiling water for one minute to remove the wrinkles. The finished fish sausage in their casings are wrapped in printed cellophane film.

b. Processing of fish ham

Small blocks (1.5 cm^3) red meat of tuna and whale are dry salted on a dressing table with salt of 3～4% by weight of the meat. In the salt potassium or sodium nitrite is added at 0.1 g per 1 kg of the meat in order to redden it. The blocks of reddened tuna and whale meat are mixed in a mixer with raw pork fat cut in rectangular form (1×1×10 cm) and the ground fish meat (this is called "binding meat", "tsunagi-niku") which amounts to 20% by weight of the reddened fish and whale meat materials. In the course of the mixing, ingredients and various condiments (the same as those added to fish sausage) are mixed in. As the binding fish meat, crushed fish meat, of which the elasticity is strong after processing, e.g., black marlin (*Makaira marlina*), or "guchi" (*Nibea schlegelii*) is employed. The mixed ingredients are stuffed into one of the available types of ham casings, which are larger in diameter than those of fish sausage. The processing of fish ham is almost the same as that of fish sausage excepting for the use of a "retainer" during the processing.

3. Differences between fish sausage and ham and Japanese style fish paste ("Kamaboko")

As above noted, in Japan from ancient times fish paste or fish pudding (Japanese style fish paste: "Kamaboko") has been processed and eaten as a favourite food. The Japanese style fish paste is prepared from various kinds of white flesh fish meat, of which the elasticity is strong after the processing of the crushed meat, e.g., "guchi" (*Nibea schlegelii*). "eso" (*Saurida argyrophanes*), "nibe" (*Scioend albiflora*) and shark meat. The procedures are dressing, filleting, crushing, grinding, seasoning, shaping and boiling. The procedures in making fish sausage resemble, at a glance, those in making the Japanese style fish paste. However, there are some differences between them. One is that the fish sausages are stuffed into sausage casing. Therefore, the period of safe preservation is increased to one month even in the summer season. Another difference is that fat or oil and spices are added to the fish sausage. Generally speaking, the Japanese like a bland taste, so preferably many kinds of seasoning materials are not added to the Japanese fish paste. But fish sausage has come to be "Europeanized" in taste to make it relished when eaten with bread. With changes in the Japanese diet, the production of fish sausage and ham is expected to increase year by year. In the future, the availability of raw materials is likely to become a serious problem. Many Japanese investigators are engaging in studies on the raw materials and the processing.

II. Raw Materials of Fish Sausage and Ham

The raw materials for the preparation of fish sausage are not necessarily certain particular species of fish such as are required for the Japanese style fish paste ("Kamaboko") of which the elasticity of the crushed meat after the processing needs to be strong. In other words, for the preparation of fish sausage, fish the elasticity of whose flesh is quite weak, can be employed. Japanese style fish paste ("Kamaboko") requires white flesh fish, but the fish sausage can use even red flesh fishes, because the material is dyed with coloring material during the processing. However, fish having a large amount of dark muscle ("chiai-niku"), such as mackerel, saury, sardine are not suitable for use in the preparation of fish sausage, because the dark muscle becomes dark blackish red in color after processing. For the raw materials of fish ham, meat from big red-flesh fishes is employed as block meat, but not as binding meat ("tsunagi-niku"), because red-flesh fish meat is generally weak in respect to elasticity after processing. At any rate, many kinds of fish are now employed as raw materials for fish sausage in contrast to the few kinds for Japanese style fish paste ("kamaboko").

1. Red flesh fish

a. Tuna

Four kinds of tuna are usually caught by Japanese fishermen; bluefin tuna ("Kuro-maguro", *Thunnus thynnus*), yellowfin tuna ("kihada-maguro", *Neothynnus macropterus*), big eye tuna ("mebachi", *Parathynnus sibi*) and albacore ("binnaga-maguro", *Germo germo*). Among them, bluefin tuna has high value as raw meat for "sushi" or "sashimi", and is too expensive to use as raw material for fish sausage and ham. The taste of the bluefin tuna becomes poor in summer, and sometimes abnormal fleshiness occurs in the meat as "jelly meat", and accordingly, when the price falls, it may be employed as raw material for fish sausage. The freshness of bluefin tuna caught in faraway oceans is apt to fall, and the fish caught with long hooks have been sometimes partially eaten by sharks. Such meat is employed as raw material for fish sausage because its price is low. Yellowfin tuna and big eye tuna are employed as raw material for canned tuna. Indian tuna (a variety of bluefin tuna) is considered in taste, so it is employed for fish sausage.

b. Marlin

There are several kinds of marlin: striped marlin ("makajiki", *Tetr-*

apturus mitsukuri), giant black marlin ("shirokawa-kajiki", *Makaira marlina*), blue marlin ("Kurokawa-kajiki", *Tetrapturus amplus*), sailfish ("basho-kajiki", *Histiophorus orientalis*) and broadbill sword fish ("me-kajiki" *Xiphias gladius*). The flesh of those fish is mainly utilized as "sashimi". If the freshness of marlin falls somewhat, the meat is employed for fish sausage because of its lower price. Blue marlin is good in taste, it has white flesh, and its elasticity is strong. Accordingly blue marlin is the best raw material for the preparation of fish sausage and ham as well as for Japanese fish paste ("kamaboko"). Striped marlin and sail-fish are deep red, but the color does not turn to blackish red during processing, as does that of blue fin tuna, because it may contain other pigments more abundant than haemoglobin.

c. Skipjack and bonito

Skipjack and bonito belong to the *Scombridae*. There are three genera: frigate mackerel ("soda-katsuo", *Auxis thozard*), bonito ("katsuo" *Katsuwonus pelamis*) and skipjack ("kitsune-katsuo", *Sarda chilensis*).

Bonito is used as a daily food, or as raw material for fish-"fushi".

Bonito fish bodies deformed owing to the freezing or icing on fishing boats are used as raw material for fish sausage. The color of bonito flesh becomes blakish red during processing, even if the pigment is fixed by the addition of nitrite. The muscle fiber of the flesh of this fish is stringy, and accordingly elasticity of the meat after processing is weak. Among frigate mackerels, the flat frigate mackerel is large and the content of dark muscle is so low that it is used for every-day food, but round frigate mackerel is so rich in dark muscle that it smells typically fishy and is poor in taste, accordingly the price is low. It is preferably used as raw material of fish sausage. The fish sausage made from round frigate mackerel is blackish in color owing to the rich amount of dark muscle ("chiai-niku").

d. Salmon

Salmon is mainly used for canning or salting in Japan. But the waste pieces of meat such as neck meat or deformed salmon body meat are employed as raw material for fish sausage.

e. Whale

There are many species of whale, among which the red meat of the blue whale ("shiro-nagasu", *Solaenoptera musculs*) and fin whale("nagasu", *Bolaenoptera physalus*) are used as raw material for fish sausage and ham as well as for frozen or salted food products. For many years, the red meat was not eaten, because of its poor taste. Big fishing companies have tried to utilize the whale red meat as above described for fish sausage ~~became~~ because of its low price.

2. White flesh fish

Generally speaking, white flesh fish meat has poor fat content but the elasticity of the meat after processing is strong. Such meat is suitable as raw material for fish sausage (as a complementary material) and ham (as "binding meat"), as well as for Japanese fish paste ("kamaboko"). Among them, the elasticity of "guchi" (*Nibea schlegelii*) of "eso" (*Saurida argyrophanes*) is strong, but that of cod ("tara", *Gadas macrocephalns*) or Alaska pollack ("sukeso-tara", *Theragra chalcogramma*) is weak.

a. Sharks and rays

All kinds of sharks and rays excepting "hoshi-same" (*Cynias manazo*), "moka-same" (or "rakuda-same", *Lamna ditropis*) and "aka-ei" (*Dasybatus akajei*) are not eaten as daily dishes because of their ammoniacal odor. They have been utilized from ancient times in Japan as raw material for Japanese fish paste ("kamaboko") owing to the strong elasticity of the meat. The cause of the strong elasticity of the meat is its rich content of urea(1).

"Ao-same" (*Isurus glaucus*), "shumoku-same" (*Cestracion zygaena*) are large in size and light red in color. However, the color of the finished product becomes white. The dark muscle in the meat becomes blackish red and hence they are not suitable as raw material for fish paste ("kamaboko"), but they can be used for fish sausage and ham. "Hoshi-same" (*Cynias manazo*), "dochi-same" (*Triakis scyllium*) "abura-same" (*Squalus sucklii*) are small in size, but the elasticity of the processed meat is strong. Meat of "onaga-same" (*Vulpecula marina*) and "mejiro-same" (*Carcharinus gengeticus*) is also strong in elasticity after processing. Among the sharks, the meat of "moka-same" (*Isurus nasus*) and of "yoshikiri-same" (*Galcus glaucus*) is weak in elasticity.

b. "Eso" (Saurida)

"Eso" (*Saurida argyrophanes*) is one of the typical catches in the East China Sea by trawling. "Eso" has been one of the typical raw materials for Japanese fish paste ("kamaboko") from ancient times. When it is fresh, its elasticity is very strong, but when a decline in freshness the elasticity falls rapidly; and especially when it is frozen, the meat becomes fragile. If such raw material of a low degree of freshness is bleached, the elasticity is regained.

c. "Guchi" and "nibe"

"Guchi" (*Nibea schlegelii*) is also one of the typical catches in the East China Sea; its taste is not good, but the elasticity is strong. Even if its freshness falls it retains its strong elasticity. "Guchi" has some defects in that it emits a metallic odor and it comes to have an astringent taste with a loss of freshness. "Nibe" (*Scioend albiflora*) resembles "Guchi". "Guchi" and "Nibe" have been considered the best raw material for Japanese fish paste ("kamaboko") from ancient times.

d. Others

Other fish which have white flesh such as "Kanagashira" (*Trichiurus lepturus*) are also caught in the East China Sea. If their freshness falls, the elasticity weakens rapidly. "Kanagashira" are unsuitable as raw material for Japanese fish paste ("kamaboko"), because the yield of the finished product is less than that of other fishes due to its big head.
In addition, it has a poor flavor. Cod ("tara", *Gadus macrocephalus*) is low fat content, and its elasticity is weak. Alaska pollack ("sukeso", *Theragra chalcogramma*) meat has almost the same chemical properties as that of cod. Flat fishes (*Pleuronectidas*) include many species. If their freshness falls the elasticity becomes weak. Squid (*Ommastrephes sloani pacificus*) is abundantly caught, so if it can be used for fish sausage, it will prove very profitable. However, it is regretfully weak in regard to elasticity. As a complementary material, it can be mixed with other raw material only up to 20 % of the total weight(2. If the squid is not skinned, the color of the meat changes to red owing to the presence of pigmentphores under the epidermis. If the skinning is carried on in warm water (about 50°C) by enzymatic action, the protein of the meat denatures and elasticity weakens. Therefore the skinning must be by

hand or soaking in boiling water (100°C) for a short time. Recently a skinning machine has been invented.

III. Processing of Fish Sausage

1. Treatment of raw materials

a. Thawing

Large blocks of frozen whale or tuna meat from the refrigerator ships are thawed in running water. When the frozen meat is half thawed, in other words, when the edge of knife can be inserted into the material, it is cut into small blocks.

b. Crushing

Fish bodies except whale and tuna are filleted removing the head, tail, fins and visceral mass, then the meat is separated with a "gyoniku-saishuki" ("fish meat separator"). The amounts of meat separated vary according to the species of fish: e.g. the yield of the meat from flat fish is 25 %, that of frozen tuna or marlin from which the visceral mass has been removed is 50~70%. The yield of the fish meat is generally about 40% by weight of the whole raw fish.

c. Soaking

The torn meat of the fish is soaked in fresh water to remove blood, fat and extraneous material. This step is called "sarashi". Soaking renders the meat white, and certain inherent bad characteristics (odour, color or taste etc.), according to the species of fish, are removed; and the valuable qualities are retained and strengthened: e.g., the elasticity ("ashi") becomes strong. But by soaking it is true that some nutritive components including protein are probably lost. Tuna meat is not bleached by soaking, but is reddened with nitrites. For bleaching, fresh water should be employed, because if salt solution is used, salt solution-soluble protein (e.g., myosins) dissolves out.

d. Draining

In order to remove excess water, the bleached meat is put in a cotton cloth bag and the whole is pressed with hand-lever or hydraulic press. Recently a bulk centrifugal dehydrator has become available. Somewhat more water should be removed from shark meat, because its protein content is less than that of other fish meat.

e. Reddening

If the red flesh meat such as that of tuna and bonito meat, having large amount of dark flesh is processed, the red color changes to blackish red. This discoloration is caused by the change of haemoglobin or myoglobin to methaemoglobin or metmyoglobin by oxidation. Formerly in order further to redden the red flesh, saltpeter (potassium nitrate) was used. The saltpeter itself has no ability to redden, but nitrite which was formed from nitrate by bacterial action combines with haemoglobin or myoglobin to form nitrosohaemoglobin or nitrosomyoglobin, which are stable and bright red in color.

$$HNO_3 \xrightarrow[\text{reduction}]{\textit{bacterial action}} 2HNO_2 \longrightarrow H_2O + \underline{NO} + NO_2$$

$$\text{Hb} \quad + \quad NO \longrightarrow \text{HbNO}$$

haemoglobin nitrosohaemoglobin
myoglobin nitrosomyoglobin

Formerly the use of nitrite was prohibited Japanese by law, but since Dec. 23, 1955, it has been permitted for fish sausage or ham on the condition that the amount of residual nitrite should be less than 70 mg per 1 kg of the finished products. If the nitrite is sodium nitrite, the amount must be less than 105 mg, whilst if it is potassium nitrite, the amount is to be less than 129 mg. The application of nitrite is carried on as follows: it is dissolved in water and the solution is sprayed onto the red meat, or 0.1 g of nitrite is mixed with 30~40 g of salt and this mixture is rubbed homogeneously onto the red flesh fish meat; the meat is then kept in cold storage for 1 or 2 days.

Recently niacin amide (nicotin amide) has also been tested for the reddening of red flesh fish meat. Niacin amide combines also with haemoglobin or myoglobin to form niacinhaemoglobin or niacinmyoglobin which are stable against heating and bright red in color. "Pinkmin" (trade name) which contains niacin amide is sold on the market for the reddening of meat sausage or ham. Yoshikawa et al.(3) have studied the use of niacin amide and ascorbic acid respectively singly or jointly for the reddening of fish sausage or ham. According to their findings, the use of niacin (0.03~0.05%) and ascorbic acid (0.02~0.05%) together was the best treatment to redden and to maintain the reddish color over a long period of storage.

The red flesh fish meat of which the freshness has become low appears blackish red, and it can not be reddened by treatment with nitrite. For such meat, if ascorbic acid is added, the methaemoglobin or metmyoglobin are sometimes reduced to their original bright red. So it is effective and permissible to add 0.05~0.5 g of ascorbic acid per 1 kg of meat.

2. **Grinding**

a. Crushing

The drained white fish meat and the reddened meat (tuna or whale) are separately crushed with a chopper.

b. Fine cutting

The crushed white fish meat, whale and tuna meat are put into an iron motar of a "silent cutter" (a "food cutter") in definite proportions which differ from maker to maker. The silent cutter has several revolving knives on a shaft. The knives are revolved at high speed by an electric motor to cut the meat and to mix it. The revolving knives do not touch the inner surface of the iron mortar, therefore the temperature of the meat being processed does not rise. Ten to 30 minutes' operation of the silent cutter is sufficient to cut the meat finely and mix it homogeneously in the motar.

As an example from a certain factory, here is a proportion of the amounts of various kinds of the meat added: tuna meat (50%), shark meat (30%), whale red meat (5%), (if complementary meat such as squid or Alaska pollack is added, the amount is less than 10%). Besides the fish meat there are added: starch (10%), sugar (1.6%), salt (3%), sodium glutamate, "ribotide" (sodium-5'-ribonucleotide) and coloring material, smoke-flavor liquid material, preservatives, spice and condiments (in total 0.4%). Instead of starch, recently gelatin made from pork skin or gluten has been added to the mixed fish meat to make a strong elasticity. The mixture of seasoning material (sugar, salt, sodium glutamate, "ribotide"), coloring material, preservatives and condiments prepared in a separate room is added to the meat in the mortar through a pipe. At the end of the operation, small cubes of raw pork fat (about

7～10%) are added to the mixed fish meat. The ingredients are then stuffed into one of the available types of sausage casings. The finished product which is prepared by cutting in a silent cutter is called "meat sausage style"-fish sausage.

c. Grinding

In some factories, the crushed with fish meat or whale meat is ground in a "stone grinder" ("raikai-ki") instead of cutting in a silent cutter in order to increase its adhesiveness. The finished product prepared by grinding in a grinder is called "kamaboko-style"-fish sausage. However, elasticity as a quality for sausage is not so important as it is for Japanese style fish paste ("kamaboko"). The grinding will be finished in 20～30 minutes. At the initial period of grinding, the meat only is put in the mortar. Near the end of the grinding period a definite amount of a mixture of seasoning and coloring material, preservatives and condiments is added to the meat being ground through a pipe just as in the use of a stone grinder. Finally small cubes of raw pork fat are added to the mixture. Sometimes the preservatives are added to the crushed meat in the initial poriod in order to secure proper homogenicity.

d. Seasoning

During the process of cutting in a silent cutter or of grinding in a stone grinder, the seasoning materials, starch and others are added to the mixture of crushed white flesh fish meat and whale near the end of the operations, which then go on for another 10～20 minutes. This seasoning materials, vegetable oil, sodium glutamate, sodium 5'-ribonucleotide, sugar, spice and condiments, smoke-flavor liquid material, salt are added in consecutive order into the crushed meat.

The starch is added near the end of the operations. The purpose of this last addition is to adjust the final elasticity of the meat. Starch is added as powder or aqueous suspension in the amount of 10% of the total weight of the mixed crushed meat. If one wishes to determine the adequacy of the elasticity, a small amount of the seasoned meat is taken out from the silent cutter or the grinder, and is heated, where upon the elasticity of the meat can be determined by the sense of touch. If the elasticity is weak more starch should be added. Such additional starch tends to impair the flavor. When starch is added as a water solution, it has been found that potato starch, because of its greater hydration activity, is more effective than wheat starch. At the present time gluten or gelatine made from pork skin is sometimes added to the crushed meat for strengthening its elasticity.

The amount of added salt is 2.5 % of the total amount of the crushed mixed meat. This is also added in company with seasoning materials near the end of the operation. A similar amount of sugar is added. Besides sugar, sweet "sake" is sometimes added.

As a vegetable oil, refined cotton seed salad oil or soy bean oil is added to the extent of 7～10% of the total amount by weight of the mixed meat. The addition of vegetable oil to fish sausage certainly differentiates it from Japanese style fish paste ("kamaboko"), because the fish sausage is prepared to be eaten with bread eating. For Japanese style fish paste ("kamaboko") the addition of oil would be unsuitable because it would weaken its elasticity. However, if the oil added to fish meat which has lost much of its freshness, the elasticity of the product becomes weak. A suitable amount of sodium glutamate is 0.1～0.3 % of the amount of the crushed meat. "Ribotide" (sodium-5'-ribonucleotide) is added at about 0.3 % by weight of the mixed meat.

As spice and condiments, pepper, garlic, ginger, cassia bark, beefsteak plant or onion are added in adequate proportions. In some factories, smoke-flavour liquor is also included. The addition of spices and condiments is important to cover the fish meat odor, especially that of whale meat. In order that a pleasant odor may be given off by fish sausage or ham, the undesirable odor of whale meat must first be eradicated by washing sufficiently, and then the odor of spices and condiments must be substituted. The kinds of spices and condiments should be two or more. Many manufacturers use five or six kinds, e.g., ginger, garlic, pepper, mace, onion, and sometimes smoke-flavour liquor. These spices and condiments are used in fine powder or soluble form. The amount added depends on the maker's experience.

As coloring material, edible red colors, use of which is permitted by law such as ponceau, amaranth, erythrosine, eosin, etc. are added. If the color of the raw material is dark, the coloring material is added after the meat has been soaked in fresh water. There are various coloring materials in one chemical compound e.g., in ponceau. The solubility, purity, color, limit of concentration, taste, pH and thermotolerance are different according to the kinds of coloring materials. Most of the permitted coloring materials do not change by heating at below 100 C. In the preparation of fish sausage or ham, red coloring materials are employed, because the main raw materials are red flesh fish meat. In Japan 10 kinds of red coloring materials are permitted.

Adachi(4) has studied the properties of the red coloring materials as shown in Table 9-2. The smaller the limit of concentration is, the more the coloring material spreads. Next, the discoloration or decoloration of coloring materials is influenced by the joint use of acids, alkalis, sugar or salt. But these changes are caused by heating at 135°C or higher. In other words, the coloring materials do not change during the processing of fish sausage or ham. At any rate, when coloring materials are used, their properties should be carefully considered.

Table 9-2. Properties of red coloring materials permitted by Japanese law

Kinds	Standard of purity	Purity of commercial samples	PH (of 1% solution)	Limit concentration※ (mg/100ml)	Color※※ (Limitconcentration ※100,000)	Taste※※※ (minimum concentration to taste)
Red No. 2 (Amaranth)	70	86.46	7.70	0.0050	dark red	tasteless
Red. No. 3 (Erythrosine)	85	90.08	8.10	0.0040	pink	bitter (0.12)
Red No. 102 (New coccine)	70	80.00	7.92	0.0050	crimson	tasteless
Red No. 103 (Eosine)	85	86.66	7.30	0.0050	yellowish pink	bitter (0.04)
Red No. 104 (Phloxine)	85	90.05	7.55	0.0040	bluish pink	bitter※※※※ (0.15)
Red No. 105 (Rose bengale)	85	87.43	7.84	0.0040		

※ Limit concentration means the minimum concentration to color.

※※ Color is that shown in the concentration of "limit concentration × 100, 000".

※※※ Taste is that in the minimum concentration of the solution. The parenthesis shows the values of the minimum concentration.

※※※※ Evil smell like iodine

As to the preservatives to be added, sorbic acid (up to 2 g per 1 kg of fish sausage) and its sodium or potassium salts, and furylfuramide (2-(2-furyl)-3-(5-nitro-2-furyl) acrylamide) (0.02 g per 1 kg of fish sausage), are permitted in Japan to be added to fish sausage and ham. The processing of the fish sausage is carried on at too low a temperature to prevent bacterial growth; accordingly the addition of preservatives is considered to be unavoidable.

e. Mixing of raw pork fat

In order to imitate meat sausage, raw pork fat is added to fish sausage. The pork fat is cut into small cubes (5 mm^3) added to the crushed-ground meat at 7～10% by weight after the meat is ground. Finally all the material is homogeneously mixed in a mixer.

3. **Casing**

a. Stuffing

The ground seasoned meat is stuffed into one of the available sausage casings by means of a machine which consists essentially of a cylinder and a piston. The ground seasoned meat is put into the cylinder, and the piston operated by compressed air pushes the meat into a casing. Recently a stuffer has been devised, by which a definite weight of the ground seasoned meat is stuffed into a casing.

The standard content weight in a casing is 130 g for fish sausage, and 244 g for fish ham, although the weight may differ with different manufacturers. Recently "special sized fish sausage" ("tokuyo"-fish sausage) (33 × 3.3 cm; 260 g) has been processed. This is so convenient for home consumption, that the amount of production has increased year by year. In addition Vienna style fish sausage (two pieces connected) is also processed, of which content net weight is 30 g for two connected pieces. The sizes of casings are as follows: (Table9-3.)

b. Kinds of casing

Formerly cellophane casings only were employed for fish sausage. Cellophane film permits penetration of moisture and fish sausage so packaged loses moisture during storage. In order to prevent such loss of moisture, water-proof cellophane (cellophane film coated with a mixture of polymer of vinyl chloride or vinyl acetate and paraffin or other plastic materials) were developed. However, this water-proof cellophane wrinkled after processing. At this juncture, "ryphan" and polyvinyliden chloride film casings appeared. It is not too much to say that the advent of such superior films has accelerated development of the fish sausage industry in Japan.

Table 9-3. Sizes of casings

Kinds	Width (cm) (half diameter)	Length (cm)	Net weight (g)
Fish sausage	5	24	130
Fish ham	9	19	224
Vienna style fish sausage	2.5	24 (two pieces connected)	30

"Ryphan" film casing (rubber hydrochloride: Ryphan Industry Co., Patent, Tokyo) is prepared from rubber latex half vulcanized as in the manufacture of toy-balloons. The toy-balloon-shaped rubber is treated with hydrochloric acid and drawn out to form sausage casings. The "ryphan" film is shrunk by heating during the processing and the film casing adheres to the content. The strong points of "ryphan" are its light and strong structure, and the fact that it is not effected by chemicals and oils or by heating and cooling. It does not permit water vapor or air to penetrate in either direction, so the flavour of the foods does not escape. The mouth of the casing can be easily opened before the stuffing procedure without the inner film surfaces sticking together. The film sheet is tough and the stuffing procedure can be carried on smoothly. This film is incombustible and does not present a fire hazard. It is also tasteless and odorless and is thus suitable for the casing foods. However it has a defect in that the rubber becomes old after some months and hydrochloric acid gas is freed from the film which then becomes fragile.

Another casing is vinyliden chloride film such as "kurehalon" of the Kureha Chemical Industry Co. Patent, resembling "Saran" of Dow Chemicals Inc. "Kurehalon" film is used for sausage casings as well as "ryphan" film. "Kurehalon" is a transparent, shrinkage and water-proof film. Its melting point is 160°C, therefore the perishables in this casing can be processed at temperatures up to 120°C. "Kurehalon" film chemically stable to fats, liquid oils, organic solvents, and is extramely hard to break, tear or puncture. The shrinkability of the film makes possible the very tight packaging of sausage and ham.

The properties of ryphan and "kurehalon" are compared in Table 9-4. Tests have yielded the following comparison of qualities of "ryphan" and "kurehalon" films. The shrinkability of "ryphan" is much greater than that of "kurehalon"; e.g., 85°C～100°C, the former is twice that of the latter. (The shrinkability of "ryphan" increases rapidly at temperature above 70°C). The shrinkability of the two films are different in the lengthwise and the sidewise direction. The shrinkability of "ryphan" in the lengthwise direction is large. This table shows that the "ryphan" film shrinks markedly after the contents are processed. The opening of the mouth of the casing which is bound with a cotton string or aluminium wire will be closed by this shrinkage thus preventing the invasion of bacteria.

Table 9-4. Properties of casing used for fish sausage

Properties	"Ryphan"	"Kureharon"	Contrast : polyethylene
Thickness (mm)	0. 028	0. 033	0. 045
Pulling strength (kg/cm^2)			
lengthwise	1. 005	893	209
sidewise	980	1, 210	173
Lengthening (%)			
lengthwise	110	43. 5	590
sidewise	113	30. 0	690
Tearing strength (kg/cm^2)			
lengthwise	32	31. 7	800
sidewise	30	20. 3	1, 000
Winding strength (number of times of winding)	50, 000/1 kg load	50, 000/1 kg load	50, 000/1 kg load
Hydrating ratio (%)	less than 0.1	less than 0.1	0. 1
Moisture penetration ($g/m^2/24$ hr.)	15	2	18
CO_2 gas penetration ($g/m^2/24$ hr./1 Atom.)	0. 6	0. 1	150

According to the values of tensile strengh (kg/cm^2) $\left(\frac{\text{maximum load to break the film}}{\text{thickness(cm)} \times \text{width(cm)}}\right)$ and elongation (%) (l'/l), "kurehalon" film is more easily torn by the same load than "ryphan" film. "Ryphan" film has more tensile strength lengthwise than in the sidewise direction; contrarily "kurehalon" has more tensile strength sideways than lengthwise. When the two films are heated at 100°C for 30 minutes or 60 minutes, the sidewise tensile strength of "kurehalon" film does not change, but its lengthwise strength becomes weak; that of "ryphan" film becomes weak in both lengthwise and sidewise directions. On the other hand, the elongation of the lengthwise dimension of "kurehalon" becomes small and heating causes the film to become fragile. The permeability of water vapor through the two films heated at 100°C for 45 minutes is 0.05 g per one casing of "ryphan" (thickness 0.05 mm) per day and 0.0022 g for the same of "kurehalon". That is to say, the two films have a very low moisture permeability.

The defects of "ryphan" film are that when the film is heated, it becomes opaque, and when heated at a comparatively higher temperature (about 100°C) for a long time, many bubbles appear its surface. Contrarily, "kurehalon" film is transparent even after the same degree of heating. However, transparency becomes a defect in that the content itself can be seen. Therefore fish sausage stuffed into "kurehalon" casing is then packaged in a covering red cellophane film.

4. Sealing

After the ground meat has been stuffed, the mouth of the casing was formerly sealed with cotton string. But recently the mouth is being sealed with an aluminium wire ring by a sealing machine. The cotton string sealing was imperfect and inefficient. When an empty casing is sealed with cotton string, if it will withstand air pressure of 3 lbs/inch^2 blown into it (held under water) with an air pump, bacteria can not enter through the opening of the mouth and the sealing is considered perfect.

The sealing machine for an aluminium wire ring seal was invented first by the Kureha Chemical Industry Co. ("Kureha Kasei Co.") and made by the Omori Machinery Industry Co., Tokyo. The "kurehalon" casing sealed with an aluminium wire ring by means of a sealing machine can withstand a pressure of 15 lbs/inch^2. It can seal 30～40 of sausages per minutes, because the operation is powered by an electric motor. "Ryphan" Industry Co. has also invented independently a "ryphan" sealing machine", "SY Type wringer". This machine can seal "ryphan" film casing with wire at rate of 50 pieces per minutes.

The Omori Machinery Industry Co. has recently made another type of sealing machine the "OKK New Packer".

5. **Processing**

The sealed casings in which ground fish meat is stuffed are processed in a boiling water tank, generally heated with steam. In large scale factories, a continuous cooker is used. The apparatus consists of two boiling tanks, a cooling tank and a short-time boiling tank in one connected unit. In the first boiling tank of which the temperature of water is kept at 75°C, the pieces of fish sausages are immersed in the water on a conveyor for ten minutes; then they are carried into the second boiling tank, temperature maintained at 85°C, where they are immersed for 60 minutes. After this cooking, the fish sausages are into a cooling water tank, at a temperature of about 10°C, where they are cooled rapidly with running water for 10 minutes. Finally, the fish sausages on the conveyor are carried into a short-time boiling tank for removal of wrinkles on the surface of the casing which have been caused by cooling. The dipping time is about one minute.

6. **Drying**

The moisture on the surface of the processed fish sausage is removed by passage through a dryer (hot air blowing).

7. **Outside packaging or drying**

By means of an automatic enveloper the fish sausage after surface drying are packaged in red cellophane paper on which labels or trade marks are printed. As to fish sausage stuffed in "kurehalon" casing, it is packed in red cellophan as above described. On the other hand, with that stuffed in "ryphan" casing, the outside of the casing is dyed beforehand, during or after the processing. When the casing is dyed after the processing, red No. 5 coloring material (Oil red XO) or a mixture of red No. 5 and yellow No. 2 (yellow AB) or yellow No. 3 (OB)(2～3 : 97～98) is dissolved in a dispersion medium and then used. The finished fish sausage is then packed in cartons for shipment to market.

8. Chemical composition of fish sausage

From many results of analyses of fish sausage, the chemical composition of the average are as follows: moisture content 68.6 %, protein 15 %, starch 6.3 %, sugar 1.8 %, ash 2.5 %, and total calories 141.5 per 100 g of sausage meat.

IV. Processing of Fish Ham

Fish ham is made from the flesh of tuna or marlin as the principal raw material and from whale meat.

1. Treatment of raw materials

The best raw material is bluefin tuna, but yellowfin tuna, big eye tuna, Indian bluefin tuna and albacore are also employed. Albacore and blue marlin meat are employed with other red flesh fish meat, because their flesh color is light red. Whale meat developes an offensive odor with a decline in freshness. To remove this odor the whale meat is soaked in running water and pressed to remove blood and is then washed thoroughly. The whale meat is cut into 3 cm cube and the red color is then fixed by addition of sodium or potassium nitrite.

The red flesh meat such as that of bluefin tuna is also cut into cubes of about 3 cm. The cubes are put in a barrel and sprinkled uniformly with salt to the amount of 3～4 % of the weight of the meat. Sodium nitrite is mixed in the salt in the proportion of 0.1 g per 1 kg of meat. If the tuna meat has been discolored by oxidation, sodium ascorbate is added in the proportion of 0.05～0.5 g per 1 kg of meat. During the procedure of the reddening the fish meat cubes in a wooden barrel preservatives such as furylfuramide (0.02 g per 1 kg of the product) or sodium sorbate (1/2,000), seasoning materials (sugar 2～3 % by weight, sodium glutamate 0.1～0.3 %, several kinds of spices (0.3～0.5 %), 2～3 small pieces of rocambole per 37 kg and 50～60 cc of smoke-flavor liquor are added to the meat.

2. Mixing and grinding raw materials

The raw material of fish ham is prepared by mixing cubes of red flesh of tuna and whale meat fixed with nitrites, raw rectangular-shaped pork fat and "adhesive binding meat" ("tsunagi-niku") as follows. In preparing the "adhesive binding meat", black marlin or "guchi" meat, of which the elasticity is strong after processing, is ground and thoroughly mixed with various preservatives, seasoning materials, spices, starch and coloring materials in a stone grinder in the same way as the raw material of fish sausage.

Raw pork back fat is washed thoroughly and is cut in rectangular sticks (1×1×10 cm). The pork fat sticks, the cubes of red meat, and the "adhesive binding meat" (20 : 100 : 20 by weight) are mixed thoroughly in a mixer. At the same time powdered starch is added at 5～6 % by weight of the red meat. Water liberated during the mixing of the meat will dissolve the powdered starch.

3. Stuffing

The mixed meat is stuffed into the ham casings by means of a stuffer. The contents weight per casing varies by makers. For example, a small pressed fish ham (round) is 160 g, a big one is 330 g; a small square fish ham is 224 g, a big one is 1, 530 g.

4. Casing

The fish ham casing is larger in diameter than that for fish sausage. The net weight is generally 224 g. The shape of fish ham is generally rectangular. To make and maintain that shape, casings stuffed with the mixed meat are put into a "retainer" made from stainless steel before processing.

5. Processing

Fish hams are processed by immersion in water at 90°C for 30 minutes and then at 85°C for 60 minutes. In big factories they are processed in a continuous cooker as same in the case of fish sausage.

6. Packaging

After removal out from the boiling tank, fish ham is dried by passing through a dryer and packaged with red cellophane paper on which names and trade marks are printed. The finished hams are packed in cartons.

7. Chemical composition of fish ham

From many results of analyses, the average general chemical composition is as follows: moisture content 61.5 %, fat 11.3 %, protein 17.5 %, sugar 1.7 %, ash 3.0 %, total calories 198.5 cal/100 g meat.

V. Spoilage of Fish Sausage and Ham

1. Keeping quality of fish sausage and ham

Fish sausage and ham are generally processed at comparatively low temperatures, because if they are processed at above 100°C, the elasticity of the ground fish meat after the processing will decrease becoming fragile and the added fat will melt. In such low temperature processed food products, only thermotolerant bacteria, but also spore-forming bacteria may survive the processing. For information on this matter, Yokoseki's results(5) on the relation between processing temperature and survival bacteria in fish sausage meat not treated with preservatives are shown in Table 9-5. In view of the above findings some preservative such as furylfuramide (AF-2, Ueno Chemical Co. Osaka), or sodium sorbate which prevent or retard the growth of the surviving bacteria are added homogeneously to fish sausage and ham meat during the processing. Some fish sausages and hams spoil within a week after processing, although almost all of them are safe for one month without spoilage. The causes of such rapid spoilage are considered to be the growth of bacteria which survived the processing because of unhomogeneous mixing of the preservatives in the meat or which entered through the seal of the casing at the time of the cooling or during storage.

Ogasawara et al.(6) have investigated the qualities of several commercial samples of fish sausage. According to their observations the

Table 9-5. Relation between processing temperature and survival of bacteria

Temp. of the center of fish sausage (°C)	Fish sausage without sugar		Fish sausage sugar added	
	Bacterial count (in 1 g)	Species of isolated bacteria	Bacterial count (in 1 g)	Species of isolated bacteria
60	5.3×10⁵	*Microc. varians* *M. epidermidis* *Bac. megatherium* *Bac. firmus*	—	—
65	6.3×10⁴	*Bac. megatherium* *Bac. firmus* *Bac. subtilis*	6.1×10⁴	*Bac. coagulans* *Bac. megatherium*
70	6.3×10⁴	*Bac. coagulans*	5.0×10⁴	—
75	3.8×10⁴	—	3.2×10⁴	—
80	—	—	1.0×10⁴	—
85	—	—	5.6×10⁴	—
88	8.1×10³	*Bac. subtilis* *Bac. megatherium*	7.5×10³	*Bac. cereus*

visual appearance was not abnormal, acidity of water-soluble substance (N/10 alkaline titration, cc) from fish sausage and ham meat was 4.61 in average, total amount of nitrogen 2.82 %, volatile basic nitrogen 32.83 mg %, trimethylamine nitrogen 19.42 mg %, histamine was not detected, coli-group was not detected, mold and yeast had not grown, bacterial count was 45×10^7 for aerobic bacteria, 67×10^3 for anaerobic bacteria, which were not pathologic. Such fish sausage and ham are sold and are safely edible.

Tanikawa et al.(7) have also isolated 1 bacillus and 3 cocci from commercial fish sausage which were not abnormal in appearance. The thermotolerance of the bacillus isolated was estimated to be 90°C heat survival for 80 minutes, 100°C for 20 minutes and destruction at 100°C for 30 minutes; thermotolerance of cocci was weak, one of them survived 80°C heat for 20 minutes.

Generally speaking, even if bacteria ~~are~~ survive in the finished fish sausage or ham meat, as long as they do not become active, the meat shows no abnormal appearance, is safely edible, and does not spoil. Therefore, the role of preservatives is very important in the fish sausage and ham industry.

2. Characteristics of spoilage of fish sausage and ham

The type of spoilage encountered with fish sausage or ham differs according to the temperature at which the material is stored. If held at 15° to 27°C for 30 days the added pork fat softens, the product developes a yellow discoloration, and a stale odor. On the other hand, if they are held at 32°～37°C, for 10 days indications of spoilage appear such as swelling of the casing, discoloration of the contents, softening and yellow discoloration of the pork fat and a stale odor. After 20 days in this temperature range spoilage is observed and the volatile basic nitrogen content increases to over 30 mg %. Generally speaking, spoilage follows next after discoloration of the meat or of the pieces of pork fat in fish sausage or ham. In other words, at the beginning of spoilage the meat around the pork fat discolors and the fat itself becomes soft. The elasticity certainly becomes weak with the onset of spoilage.

3. Types of spoilage of fish sausage and ham

If the casing is properly sealed, any spoilage which occurs is attributed to microorganisms originally present in the fish meat and other materials. Several types of spoilage have been observed in fish sausage and ham in which formation of gas, changes in pH, and amount of volatile basic nitrogen, bacterial count, color, flavor and taste, and deformation of constituents of the meat muscle tissue occurred.

Types of the spoilage may be listed as follows:

(1) Gas formation: Swelling of casing owing to the generation of gases such as ammonia or carbondioxide by various species of bacteria.

(2) Acidic formation due to growth of non-gas-forming bacteria resembling those which cause "flat-sour" of canned foods.

(3) Putrefactive odor with or without gas formation.

(4) Softening: Softening of the meat to mud-like consistency owing to the action of proteolytic bacteria.

(5) Discoloration: The discoloration begins around the meat at the mouth of the casing, and spreads to all the visible surface of the contents; Sometimes the casing partially swells.

(6) Liquefaction: Liquefaction of meat occurs between the casing and the surface of the contents, sometimes accompanied by partial swelling of the casing.

(7) Recently a new type of spoilage characterized by the presence of small light "black" or "brown" spots on the surface of the fish sausage inside of the casing has been observed.

Among the cases of spoilage characterized by gas production, one, that of fish sausage or ham of which the surface of the meat has discolored to yellowish white, but the inner part is not discolored, was caused by bacteria and air which gained entrance through the opening of the mouth of the casing. The causative microorganisms were of low heat resistance. Another type of spoilage that in which the inner part is discolored, may be caused by heat resistant bacteria from raw materials (meat, fat or spices and condiments). In the case of gas formation and swelling of the casing ammoniacal and unpleasant odors are sometimes noted.

"Acidic spoilage" characterized by changes of color, taste or elasticity of the meat without swelling may be caused by non-gas-forming and thermotolerant bacteria originating from the raw materials. Putrefactive spoilage with or without gas formation is also caused by bacteria originating in the raw materials.

"Softening" can be noted from the outside of the casing by pressing the fish sausage or ham with the fingers. In this type of spoilage small localized areas of softening are sometimes observed. Such spoilage is attributed to heat resistant bacteria which are contaminants of the raw material.

Discoloration and liquefaction are accompanied with other types of spoilage and seldom occur singly.

When actual spoilage is not evident, one sometimes detects only a loss of taste or discoloration of the fish sausage or ham, these conditions may be due to the aging of starch and oxidation of pork fat in the meat.

4. Detection of spoilage in fish sausage and ham

It is difficult to identify the type of spoilage of fish sausage or ham because they are special processed foods stuffed in air-tight casings and containing added preservatives. Thus the characteristics of spoilage may differ according to the manufacturers and the source of raw materials. The determination of the kind of spoilage is based upon organoleptic, chemical and bacteriological tests. However, it is difficult to detect incipient spoilage by means of quantitative chemical tests such as the estimation of amounts of volatile basic nitrogen and volatile acids, pH value, or by bacterial count.

The following considerations and factors contribute to the difficulty of measuring incipient spoilage. If the estimation of the amount of volatile basic nitrogen, of which 30 mg % generally indicates incipient spoilage of the raw fish meat is employed for fish sausage or ham, even those products containing less than 30 mg % sometimes are found to be completely spoil~~age~~ed, while, those containing above 30 mg % are sometimes safely edible. This may be due to the fact that fish sausage or ham is not made from one fish meat alone, but from a mixture of fish and other raw materials. For example, in fish sausage or ham with added sugar, until the sugar is exhausted by bacteria, the volatile bases generally do not increase. If albacore meat is employed in making sausage, the amount of volatile basic nitrogen in the fish sausage exceeds 30 mg %, even if the albacore meat was fresh. Therefore it is dangerous to judge the incipient spoilage of fish sausage or ham on the basis of 30 mg % level of volatile basic nitrogen. Fish meat held under anaerobic condition is likely to become acidic rather than alkaline. Although the estimation of the amount of volatile acids has been tried, judgment by this test is difficult for the same reason in the estimation of volatile basic nitrogen.

As to bacterial count, fish sausage or ham generally contains $10^2 \sim 10^3$/g of aerobes after processing, which increase to 10^7/g during storage, at which point the product become completely spoiled. In fish sausage or ham, it is of course under anaerobic conditions, that anaerobes grow. So it is necessary also to estimate the number of anaerobes. Much time is needed the estimation of the numbers of aerobes and anaerobes.

The estimation of elasticity of fish sausage or ham is a positive way to distinguish complete spoilage, but it is difficult to judge incipient spoilage. At present the organoleptic test is the best method of judgment in cases of a large daily production of fish sausage or ham. However, the inspectors should know the relation between the results of organoleptic test and other scientific tests and more objective tests.

5. Kinds of bacteria which cause the spoilage of fish sausage and ham

Yokoseki(8) has pointed out the respective typical species of bacteria which cause the various types of spoilage. According to him *Lactobacillus. sp.* (aerobic or anaerobic, non-thermotolerant bacteria) and *Clostridium sp.* (anaerobic, sporeforming, thermotolerant bacteria) were found for "gas formation"; *Lactobacillus sp.* (non-sporeforming and non-gasforming bacteria) for the "acidic spoilage"; *Streptococcus sp.* (facultative anaerobic bacteria, non-thermotolerant) for the "discoloration spoilage".

Yokoseki(9) has isolated a causative bacteria of "spot spoilage" which in one type of deterioration in fish sausage. He found that about 32 percent of the samples stored at 37°C showed reddish-brown and reddish-purple spots on the surface after 30 day's incubation, but no such deterioration occurred in the samples kept at 30°C within the same period. Viable bacteria to the extent of $10^5 \sim 10^7$ per gram were found in the spotted portions of the spoiled products. Sixty eight isolates of which 63 were identified as *Bacillus coagulans* which belongs to the group of thermophilic bacteria, while the rests, isolated from one sample, were also *Bacillus,* but were not identical with any of the known species. He could reproduce typical spot deterioration on fish sausage through an experiment by inoculation with spores of *Bac. coagulans* strain.

As to the chemical properties and the mechanism of the outbreak of black spot discoloration, a study has been made by Tanikawa et al.(10) A sulfur-containing compound in onion which is incorporated into fish sausage, is decomposed by the bacterium to evolve hydrogen sulfide. The hydrogen sulfide reacts with iron in the fish sausage to make iron sulfide which causes the black spot discoloration. The bacterium has strong resistance against sorbic acid and various kinds of furan derivatives except furylfuramide.

Bacteriology of the deteriorations of fish sausage was reviewed by Simidu and Aiso.(11) The presence of large numbers of Gram positive bacteria was observed in the surface area of gassy or softened sausages. The cores of the spots were found to consist of masses of Gram positive bacteria grown in the enmeshing structure of the tissue. Most of the cultures isolated from the spoiled sausages classified into three distinct groups of genus *Bacillus,* i.e. *B. coagulans, B. sphaericus* and a species resembling morphologically and physiologically to *B. firmus* except for its anaerobic production of gas from nitrate, inability to hydrolyze starch and non-inhibitory growth to glucose media.

The surface gassiness was confirmed to be due to the production of gas from nitrate by the denitrifying bacteria of the last group. The bacteria of this group were also found to form spots as the result of localized growth. They also caused the softening of the sausage on its surface when large amount was inoculated. The members of *B. coagulans* as well as of *B. sphericus* seemed to cause spots, and color shape of which being varied according to the materials and manufacturing conditions.

As to *Clostridium*, Ino(12) and Kasai(13) have isolated *Cl. welchii* and *Cl. sporogenes*, which are thermotolerant, and have found that if these bacteria are inoculated into fish sausage, spoilage appears. In particular, *Cl. welchii* has caused food poisoning although rarely, so it is significant from the view point of public health. These bacteria originate from the soil. Among those bacteria causing various types of spoilage, non-thermotolerant bacteria appear to have come through pinholes or through the opening of the mouth of the casing during the cooling in water or during storage. The thermotolerant bacteria which survive after the processing seem to have come from the raw materials of fish sausage or ham.

VI. Origin of Bacteria in Spoiled Fish Sausage and Ham

1. Bacteria in raw materials

Bacteria in spoiled fish sausage or ham are considered to have come from raw materials, or from equipment and facilities used in various steps involved in making the products, e.g., grinder, mixer, stuffer. There have been many investigations upon the cause and control of contamination of raw materials and equipment(11)(12)(13). According to Tanikawa et al.(7) various raw materials have been contaminated by bacteria as shown in Table 9-6.

Table 9-6. Bacteria contamination in raw materials for fish sausage and ham

Raw materials	Bacterial count	Number of thermotolerant bacteria ※
I. Main raw materials		
Tuna (blue fin tuna) meat	1.2×10^{6}	0
White marlin ("makajiki") meat	3.5×10^{6}	0
Big eye tuna ("mebachi") meat	2.2×10^{7}	0
Sperm whale meat	5.2×10^{6}	0
Squid meat	1.2×10^{4}	0
Shark ("mejirosame") meat	5.2×10^{6}	4.2×10^{2}
Shark ("ubasame") meat	1.6×10^{4}	4.7×10^{2}
Pork red meat	5.4×10^{6}	0
Pork fat	1.2×10^{6}	0
Pork oil	1.2×10^{4}	0
II. Complemental materials		
Wheat starch	2.9×10^{2}	1.2×10
Corn starch	2.0×10^{4}	5.2×10
Potato starch	2.8×10^{3}	2.0×10^{3}
III. Condiments		
Coriander	2.6×10^{7}	1.4×10^{4}
Ginger	2.1×10^{4}	1.2×10^{3}
Nutmeg	1.6×10^{3}	0
Pepper	6.4×10^{3}	0
Cayenne	2.0×10^{3}	1.1×10^{2}
Curry powder	1.2×10^{3}	1.0×10^{2}
Chinpi	0	0
Garlic	1.2×10^{3}	0
Onion	5.5×10^{6}	0
Sodium glutamate	4.4×10^{3}	0
Sugar	150	20
Salt	0×10^{4}	0

IV. Coloring materials		
New coccine (Red No. 102)	0	0
Rose bengale (Red No. 105)	2.0×10^3	0
V. Additives		
Miton (SPK-21) (a kind of polyphosphate)	0	0
Polygon-M (a kind of polyphosphate)	2.0×10^3	4.0×10^2
Sodium succinate	0	0
Ascorbic acid	1.2×10^3	0
Neo-furasukin (a mixture of nitrofurylacryl amide, nitrofurazon and lactose 8 : 2 : 90)	0	0

※ Thermotolerant bacteria are those which have survived after heating at 85°C for 30 minutes.

Of course, the degree of the bacterial contamination differs according to the producing area and methods of transportation of materials. The general picture of sources of contamination shown in Table 9-6 is quite similar to that reported by other investigators.(14)(15)(16) As seen in Table 9-6, the principal raw materials are generally contaminated by bacteria, but relatively few thermotolerant bacteria are found. Such contamination may be caused by the preparation treatments or washing with water. The reason why shark meat is highly contaminated seems traceable to the mode of transportation and its treatment. For example, shark, of which the bodies are generally large, are usually transported in the round, therefore they are left on decks of ships or on the floor of fish markets which are contaminated with soil borne thermotolerant bacteria. Accordingly, such raw materials should be treated with care.

It is a surprising fact that condiments are heavily contaminated with bacteria, some of them thermotolerant. This fact can not be passed over, because the presence of thermotolerant bacteria seems to be one of the causes of spoilage. The presence of thermotolerant bacteria in spices and condiments has been reported by several investigators.(16)(7) Recently attempts have been made to prepare sterile spices and condiments.

The presence of thermotolerant bacteria in starch has been reported by Kimata(17)(18)(19) and others.(20)(21) Of the various kinds of starch,

potato starch contains the largest number of bacteria, amongst which thermotolerant bacteria comprise approximately 70 %. Kimata(18) has isolated *Bac. subtilis* and *Bac. circulans* from spoiled Japanese fish paste ("kamaboko"). These bacteria were observed to be similar to those found in potato starch employed for making the "kamaboko". He has also isolated *Bac. megatherium*, and *Bac. cereus* from potato starch. He has sounded a warning that some of the spoilage bacteria may certainly come from potato starch. Kimata has also isolated *Bac. subtilis* and non-forming bacteria such as *Flavobacterium sp., Carynebacterium sp., Micrococcus sp.,* and *Sarcina sp.,* from wheat starch. Recently "sterilized potato starch" (below 100 bacteria per 1 g) has been manufactured by employment of an automated processing operation or high temperature short time drying. The decrease in number of bacteria in the potato starch may be attributed in part to the decrease in the time required for completion of the manufacture, in which there is no time for contamination as there has been in the earlier procedure, and to the employment of high temperature sufficient to kill bacteria attached to the potatoes. In fact, Suzuki(21) has found some starch having 10^2 order of bacteria, which has been manufactured in modern starch factories.
There is a bright future in the manufacturing of sterile starch. Suzuki has also suggested employment of a sulfite process to decrease the number of bacteria.

The bacterial contamination in coloring materials or in seasoning materials (sodium glutamate and sodium succinate and sugar, salt) are considered to be due to bacteria in the air.

2. Contamination of factory and equipments

It is important to know to what extent the factory facilities, equipments and half-finished goods during processing may be contaminated with spoilage bacteria, because such bacteria have also been found to come from such sources as the factory floor or equipment.

Tanikawa et al.(7) have investigated the contaminations of machines, equipment, factory environment (floors, soil around the factory, hands of workers) and water in a fish sausage factory. Their findings are shown in Table 9-7.

Table 9-7. Bacterial contamination in factory environments

Place of sampling	Bacterial count	Number of thermotolerant bacteria
I. Raw material throughout		
Manufacturing processes (half-(finished goods)	6.0×10^3	0
Meat in a grinder (for ham)	1.0×10^4	0
Meat in a mixer	6.0×10^3	0
Meat in a silent cutter	1.2×10^4	4.2×10^3
Meat in a stuffer		
for sausage	1.5×10^4	4.0×10^3
for ham	4.0×10^3	0
II. Equipment and apparatus		
Dressing table	1.4×10^7	1.2×10^3
Fish cage	5.5×10^7	0
Conveyor		
for raw materials	2.2×10^6	0
for fish sausage	2.0×10^3	0
III. Water in the factory		
Washing water for raw materials room	5.5×10^7	0
Well water	7.1×10^3	0
Cooling water	1.2×10^7	0
Water heated at 85°C	0	0
IV. Facilities in factory		
On floor in raw materials room	5.5×10^7	7.9×10^3
On floor in refrigerating chamber	6.7×10^6	7.6×10^2
On floor in chilling chamber	2.2×10^6	2.2×10^2
On floor in cooking room	5.5×10^6	0
On floor in processing room	3.4×10^7	0
In thawing water tank	1.2×10^7	0
At the out-put of silent cutter	5.5×10^3	0
At the out-put of stuffer (for sausage)	6.7×10^3	4.0×10^2
At the out-put of stuffer (for ham)	4.0×10^3	0
On the casing board	2.4×10^4	0
In soil around the plant	3.2×10^3	4.0×10^2
Hands of workers (average)	5.5×10^7	0

As seen in Table 9-7, it is interesting that in meat during the grinding or mixing procedures no thermotolerant bacteria were found, but that in ground seasoned meat which is pushed out from the stuffer into the sausage casing, after mixing with complemental materials and condiments, there have been found many thermotolerant bacteria. From these observations it seems that the presence of thermotolerant bacteria may traceable to the admixture of complemental materials or spices and condiments. The fact that in the mixture being made for ham when it was pushed out from the stuffer into fish ham casing, there were no thermotolerant bacteria, is considered to be due to the absence of starch in the "adhesive binding meat" ("tsunagi").

Instruments and articles of equipment such as dressing tables, fish meat boxes, conveyors and other parts which are directly in contact with raw fish meat were found to be highly contaminated with thermotolerant bacteria; among them the dressing table is especially seriously contaminated. This condition has also been observed in the case of fish canneries(22)(23). Except for water heated at 85°C, washing or cooling water has a large number of bacteria, but they are not thermotolerant. If the processed fish sausage or ham is cooled in cooling water containing a large number of bacteria, they are likely to gain entrance into the casing through the opening of the mouth of the casing or pinholes. The cooling water should be sterilized with chlorine before use. As to the environment of the factory, on floors of the raw material room, refrigerating chamber, or at the out-put of the stuffer there are found many thermotolerant bacteria, which spread into raw materials and cause the post-processing spoilage of the fish sausage. Care must be taken to avoid contamination with soil bacteria, which are highly thermotolerant.

Kasai and Matsui(24) have investigated the falling of the floating bacteria in the air in the fish paste ("kamaboko") factories, and found that the number of such bacteria varies with temperature, humidity, air current and the kinds of dust in the factories. They state that the more unsanitary the inside of the factory is, the larger the number of air-borne bacteria which fall. In particular, there are many bacteria in the air near a stone grinder ("raikai-ki"). Kasai and Matsui(24) and Noguchi and Tsukuda(15) have pointed out that the contamination of the air may be due principally to starch being added into the material as it is passing through the grinder. In a modern fish sausage factory in which automation is employed transportation by conveyor and with each room is isolated by glass walls, there are few air-borne bacteria.

3. Thermotolerance of bacteria which have survived in fish sausage or ham

Yokoseki et al.(25) have found spore-forming bacteria of 10^3/g which survived even after the center of fish sausage was brought to 88°C temperature during processing. Further, Akamatsu(26) has found many commercial sausage containing aerobic bacteria of $10^2 \sim 10^3$/g and anaerobic bacteria of $10 \sim 10^2$/g. Tanikawa et al.(7) have isolated three kinds of cocci of low heat resistance (destroyed at 80°C for 10 minutes, 85°C for 5 minutes) from swollen spoiled fish sausage, and also a thermotolerant spore-forming bacillus from spoiled softened fish sausage. They have made it clear that the thermotolerance of the isolated bacillus raised according to the concentration of the spores. According to their observations, in the case of 10^3/cc spore concentration the bacillus survived heating at 85°C for 90 minutes, but was destroyed at 95°C for 50 minutes, at 100°C for 10 minutes. In the case of 10^5/cc of spore concentration, the bacillus survived at 100°C for 130 minutes, at 105°C for 40 minutes and was destroyed at 110°C for 60 minutes and at 115°C for 20 minutes. This bacterium was identified as *Bac. circulans*; it has been isolated from spoiled softened fish sausage by Yokoseki(25). These thermotolerant bacteria will survive the usual commercial processing of fish sausage. The fact that the non-thermotolerant cocci survive in normal commercial fish sausage will be explained as follows: Almost all of the cocci may be destroyed by commercial processing, but some of them will survive in small number, and they will multiply during storage. Another explanation is that: non-thermotolerant cocci will survive during the processing, because when they multiply in the fish meat, the thermotolerance will be increased. In fact, the thermal death points of bacteria or cocci in fish meat are higher than those in bouillon or physiological salt solution. Of course, the invasion of cocci into fish sausage after the processing, through the opening of the mouth of the sausage, can be considered as one of the reasons for the presence of non-thermotolerant cocci.

4. Outside bacteria contamination of fish sausage or ham

Pathways through which processed fish sausage or ham may be contaminated from outside are pinholes in the casing film or the opening of the tied mouth of the casing. As in canned foods, if the sealing of the container is not absolutely tight, the content will be spoiled by invading bacteria from the outside, even if the processing was adequate.

(a) Invasion of bacteria through pinholes and the mouth of casings

The casing films sometimes have pinholes, even though they were carefully manufactured. But if the pinholes are very small, bacteria will not enter through them. Simidu(27) has studied the invasion of bacteria through pinholes, and reported that if the size of a pinhole on the surface of "ryphan" film is 80 μ in diameter, bacteria can not invade, but if the size is larger than 100 μ, bacteria may enter. As to "kurehalon" film, if the size is smaller than 50 μ, bacteria can not invade, but larger than 70 μ, bacteria may invade and contaminate the content. The reason that even if there are many small pinholes on the surface of the casing films, bacteria can not enter through them after the processing is that films shrink to close the holes during the heating. As "ryphan" film shrinks more than "kurehalon" film, the former can prevent the invasion of bacteria, even if it has larger size pinholes than the latter.

The sealing of the mouth of the fish sausage or ham has been formerly done by hand tying with cotton or linen strings or with vinyl chloride or "ryphan" strings. In case of hand tying, the strength of the tie differs by workers or to other factors, accordingly imperfect seals through which bacteria will invade the content are common. At present most sealing is being done with an aluminium wire ring by a sealing machine. Thus, the tightness of the tie is uniform as adjusted on the machine. Since the invention of the sealing machine, the trouble by the invasion of bacteria through the opening of the mouth of the casing has been remarkably decreased.

(b) Relation between the tightness of tying the mouth of the casing and the invasion of bacteria

The Kureha Chemical Industry Co. made a study of 60 pieces of fish sausage as to the relation between the tightness of tying (pressure, 1b/inch^2 by an air-tester) the mouth of the casing and the ratio of the number of spoiled fish sausages (judged by the discoloration of the content at the casing mouth). The following results were obtained. As seen in Table 9-8, if the mouth of the casings is tied with linen string, the stronger the tying, the less the ratio of spoilage; it is desirable to tie the mouth of the casing at above 6~8 1b/inch^2 pressure. If the mouth was tied with vinyl chloride string, the ratio of spoilage was less than with linen string. This may be due to the greater shrinkage of vinyl chloride string than hemp string during the processing.

Table 9-8. Relation between the tightness of tying of the mouth of the casing and the ratio of the number of putrefied fish sausage

Kind of string / Strength of tying	Hemp string			Vinyl chloride string		
	Number of samples of fish sausage	Number of spoiled fish sausage	Ratio of spoilage (%)	Number of samples of fish sausage	Number of spoiled fish sausage	Ratio of spoilage (%)
Below 1 1b/inch^2	40	7	17.5	39	0	0
2~3 〃	40	9	22.5	40	1	2.5
4~6 〃	40	9	22.5	40	0	0
6~8 〃	40	3	7.5	40	2	5.0
10~18 〃	39	2	5.1	40	1	2.5
Above 20 1b/inch^2	40	1	2.5	40	0	0

The sealing with an aluminium wire ring by a sealing machine is comparatively satisfactory. The sealed ring for "kurehalon" with stands a pressure of 20 1b/inch², up to a maximum pressure of 23~25 1b/inch². The withstanding of such high pressures indicates prevention of invasion of bacteria, as has been indicated in Table 9-8. However it is noticeable that, if meat scraps are pinced between the films at the mouth of the casing during sealing, the seal may be imperfect thus allowing bacteria to invade into the contents, even if the tie is tight.

5. Contamination by cooling water

Bacteria which invade through the opening of the mouth of the casing or pinholes may be not only those in the air, but also those in the cooling water. Cooling is carried out after the processing of fish sausage or ham in order to prevent the growth of thermophiles. By cooling, the content of fish sausage or ham is caused to contract and the inside of the casing developes a slight vacuum, with result that cooling water may be sucked in, with a resultant contamination of the product. Yokoseki(25) have found bacteria from cooling water which contaminated the product. He made samples of fish sausage and cooled them in city water and in water contaminated with the bacteria isolated from a sample of spoiled sausage. The fish sausage cooled in city water did not spoil; on the other hand, the samples cooled in contaminated water spoil in all cases. It follows that the sealing of the casing should be properly carried out and the cooling water should be disinfected if it is all possible.

VII. Adhesion of Meat Material on Casing

It has been known that the keeping quality of sausage products is closely related with the degree of adhesion of meats to the casing. However, neither the method of measuring the adhesion nor its mechanism has been investigated, even the phenomenon may be caused by the similar way as that found in canned fish. Yokoyama(29) has developed two methods to estimate the degree of adhesion, namely the measuring of adhesion strength and that of weight of meat attached to film. Applying the method, effect of different species of fish and their grade of freshness on the rate of adhesion was measured, and the following results were obtained.(30) Fat contents of fish meat are not related to meat adhesion on casing, but water contents of fresh fish meat are correlated to meat weight attached to the casing. Though it has been reported that myosin, myogen, proteins of fish muscle are connected with gel-strength of "kamaboko", these proteins may possibly not be correlated to meat adhesion, namely, adhesion strength and weight of meat attached to film. When quantity of stroma protein of fresh fish meat is increased, adhesion strength of boiled fish cake made of that fish meat is increased. As regarding the freshness of fish meat on the rate of adhesion, both of adhesion strength and weight of meat attached to film are decreased with deteriorating freshness of fish. The reason of this fact might be due to inactivation of polar groups through denaturation of proteins in fish muscle with deterioration of the freshness.

VIII. Effects of Preservatives

The addition of preservatives to fish sausage is not only effective in preventing the growth of bacteria which survive the processing, but also is effective in reducing the thermotolerance of the bacteria present in raw meat during processing.

1. Preservatives permissible for use in fish sausage and ham

Preservatives whose use is allowed by law in Japan in fish sausage and ham are furylfuramide ("AF-2"; Ueno Pharmaceutical Co., Osaka) (2-furyl-3(5-nitro-2-furyl)-acrylamide) and sorbic acid and its sodium and potassium derivatives. Level of use of furylfuramide is not over 0.02 g per 1 kg of fish sausage and ham meat, and sorbic acid is up to 2 g.

Furylfuramide is dark red in color, an effective germicide and it has the quality of its melting point is 152°C, and not being affected by acids and alkalis. It is dissolved with difficulty in water (1 : 8, 000), but it is comparatively easy to dissolve in alcohol (1 : 110), and in propylene-glycol (1 : 90).

The antimicrobial activity of furylfuramide is shown in Table 9-9, in comparison with those of nitrofurazone and 5-nitro-2-furylacrylamide which are being used in past. The antimicrobial activity of furylfuramide is very high for various bacteria, but low for fungi and yeasts. As shown in Table 9-9, furylfuramide is more effective than nitrofurazone and nitrofurylacrylamide in antimicrobial action. Activity of furylfuramide is so high for thermophiles that it can be use for a preservative of fish sausage and ham.

Table 9-9. Antimicrobial activity of nitrofran derivatives (μg/mg) (31)

Organism	Furylfuramide	Nitrofurazone	Nitrofurylacrylamide
Ps. aeruginosa 8231	12.5	50	50
Ps. gelidicala 8116	12.5	50	50
Ps. fluorescens 8134	50	100	100
Ps. chlorophis NRRL B-5	25	100	100
Ps. graveolus 8256	2.5	100	25
Ps. riboflavinus 8257	25	100	50
Ps. fragi 8255	25	100	100
B. subtilis (219) 8039	0.25	5.0	0.62
B. natto 8104	0.25	2.5	0.5
B. megaterium 8036	1.0	2.5	2.5
B. brevis 8138	0.31	10	5
B. cereus 8032	0.31	2.5	1.25
B. mesentericus 8043	0.16	2.5	0.625
B. pumilus 8192	0.16	5.0	1.25
Ach. candicans 8005	3.10	50	12.5
Ach. butyri 8004	50	100	100
Aer. cloacae 8022	5.0	12.5	6.25
Aer. aerogenes 8019	1.25	20	10
E. coli 8063	0.16	10	2.5

Furylfuramide is one of the nitrofran derivatives, and is decomposed by heating with meat proteins. Obatake and Matsuda(32) have investigated on the behavior of furylfuramide and nitrofurazone in fish sausage processing. The quantities of furylfuramide and nitrofurazone mixed in raw ground fish meat were constant during a four hours storage at 5°C. However, the quantity of furylfuramide decreased rapidly for the first 10 minutes after it was mixed in the raw ground meat and then it remained constant. As to the effects of heating time and temperature on furylfuramide and nitrofurazone in fish sausage, the quantities of the two nitrofurans decreased inverse ratio to increased heating time and temperatures. The quantity of furylfuramide decreased gradually during storage at 37°C to a small trace amount at the end of 30 days storage.

Further study on the preservative effects of furylfuramide and nitrofurazone and their decrease during storage have proved that a larger quantity of furylfuramide remained in the lower pH sausage after the boiling process and storage.(33) However, a higher pH value in the sausage might not be a cause of the decrease in furylfuramide in fish sausage during the storage. After the boiling process, the larger the quantity of furylfuramide added, the larger a ratio remained. The amount of decrease during the storage time was effected by the storage temperature. A larger quantity of furylfuramide remained at 30°C than at 37°C.

Sorbic acid (2,4 hexa dienoic acid) having chemical formula $CH_3:CH:CH:CH:CH:COOH$ is a white crystalline substance, tasteless, possessing of slight smell resembling fat, heat-stable, and non toxic. Its solubility is 1.4 g in 1,000 ml of water at 20°C, 16 g at 80°C, 38 g at 100°C. The level of use is up to 2 g for 1 kg of fish meat paste. The single use of sorbic acid or its salts is inferior in effective germicidal power, so it is sometimes used in combination with furylfuramide in fish sausage or ham.

2. **Effects of preservatives in combination use**

Each preservative has its respective germicidal peculiarity for each species of bacteria. Therefore the use of single preservative can not be effected for germicidal purpose on many species present in fish sausage or ham.

Ueno(34) has studied the effects of preservatives used jointly. *Bac. mycoides* and *Bac. mesentericus* which are often found in fish sausage or ham, suspended in physiological saline solution to which nitrofrazon, pentachlorphenol and vitamin K were added separately or jointly in respective concentrations of 50 ppm. The suspended solutions were heated at various temperatures. Results showing relations between the logarithm of the number of surviving bacteria and heating time (thermal death rate curve) were obtained as shown in Figs. 9-1 and 9-2.

As seen in Figs. 9-1 and 9-2, germicidal effects did not appear in the initial period of the heating, but remarkable effects appeared after certain

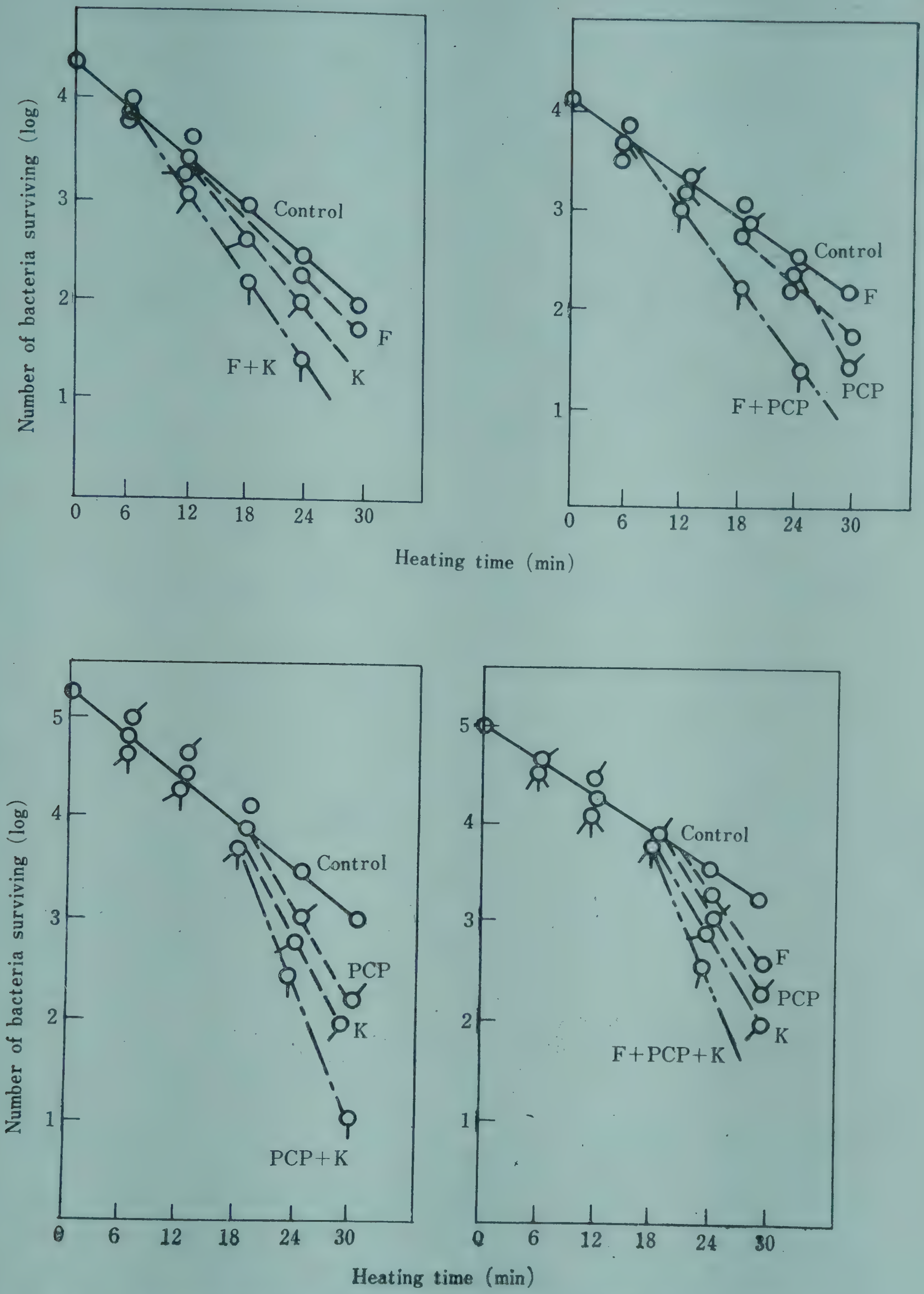

Fig. 9-1. Relation between the logarithm of the number of *Bac. mycoides* surviving heating in solution to which various preservatives had been added.

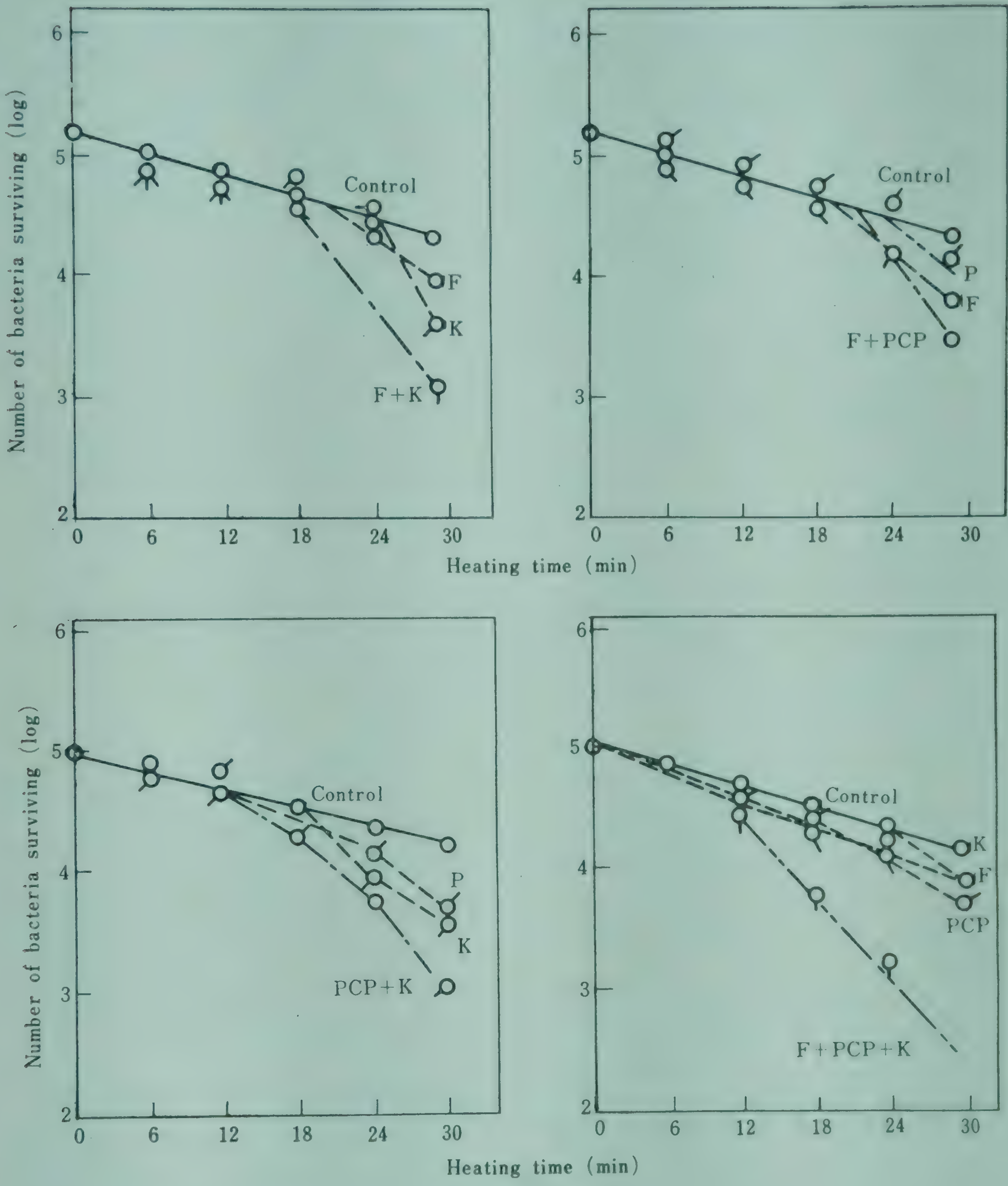

Fig. 9-2. Relation between the logarithm of the number of *Bac. mesentericus* surviving heating in solution with various preservatives added.

intervals, as shown at the points of change in slope of the curves. When the preservatives were used jointly these points were very significant; those in cases of the use of two or three kinds of preservatives jointly appeared earlier than in the curves showning the use of single kind of preservative. In other words, the use of two or three kinds of preservatives jointly is more effective for germicidal purposes than the use of a single preservative. Those effects have been observed also by Tetsumoto, Tozawa and Okitsu(35) in storing raw fish meat at low temperature. The greater the number of preservatives used, the shorter the time before which the germicidal effect appears. The germicidal effect obtained by the use of preservatives is more pronounced at lower temperature (below about 80°C)(34).

Recently in many fish sausage factories, furylfuramide and sorbic acid have been employed jointly within the levels of permitted use. With their use fish sausage or ham can be preserved for a month even in the summer season.

It is favorable to fish sausage being mild acidity from the standpoint of prolonging the shelf life of the product, because growth of spoilers is retarded in acidic media. However, lowering the pH of the product by the addition of acid affects appreciably the physical properties of the sausage. Okada and Komori(36) have found that certain lactones such as arabono gamma lactone or glucono delta lacton could be used for adjusting the acidity of fish sausage without decrease its elasticity. Okada and Takesue(37) have carried out further study to ascertain the effect of lowering the pH of fish sausage on the shelf life of the product by application of arabono gamma lactone. When the pH of fish sausage containing no chemical preservatives was brought to 5.5, there was no indication of deterioration even after 2 weeks storage at 38°C. On the contrary, spoilage companied with gas formation was occurred during 5 days storage among all control samples (pH 6.1). With the used of chemical preservative such as sorbic acid, acidification of the product resulted in significant prolongation of the shelf life. This might be explained by the fact that sorbic acid is more effective in acid medium. The fish sausage prepared with adding furylfuramide and the lactone can also be prolonged the shelf life, because inactivation of the preservative during heating is reduced at lower pH range.

IX. Quality of Standards of Fish Sausage and Ham

The Japanese Agriculture and Forestry Ministry early 1962 year adopted quality standards for fish sausage and ham in accordance with the Agriculture and Forestry Products Standards Law. They became effective on March 1, 1962. Based on the standards, fish ham and fish sausage are graded and assigned score according to color, flavor, and texture.

1. **Fish Ham**

Definition: Fish meat (including whale meat and meat of aquatic animals other than fish) seasoned with salt, or a mixture consisting primarily of fish meat mixed with pork, beef, horse meat, mutton, rabbit meat, or poultry meat seasoned with salt, and combined with binding meat (consisting primarily of ground fish meat, to which have been added additives such as oil, flavoring, and starch to give it binding strength), and packed in a casing, then sealed and steamed.

2. **Fish Sausage**

Definition: Ground fish meat or a mixture consisting primarily of ground fish mixed with ground pork, beef, mutton, horse meat, rabbit, or poultry, to which have been added additives such as oil, seasoning, and starch for binding strength, packed in a casing and sealed, then steamed or boiled. Contents may be smoked before packing in casing.

3. **Standards**

Quality will be graded a point system for appearance, flavor, and texture. Average score must be higher than 3.0 points and for each category a score higher than 1 point must be scored.

a. Appearance:

1. Contents must not be deformed.
2. Seal must be perfect.
3. Contents must not be damaged.

4. Separation must not occur between casing and content.
5. Contents must not be pressed into sealed portion of casing.

b. Starch content:

Must be less than 9 percent for fish ham and less than 10 percent for fish sausage.

c. Other substances:

There must be none.

d. Net weight:

Net weight must correspond with weight indicated on package.

e. Label:

1. Packing date must be clearly indicated.
2. Names and addresses of manufacturer and distributor must be shown.
3. Words and pictures must correctly describe contents and must not convey a misleading impression.

4. Grading Method

Fish ham and fish sausage will be graded as follows:

a. Color score:

4 to 5 points	Contents are appropriately colored; pigments in the meat used for binding purposes are not noticeable; color of casing has not discolored contents.
3 points	Coloring of contents generally acceptable; pigments in binding meat almost unnoticeable; color of casing has not noticeably discolored contents.
2 points	Contents excessively colored; pigments in binding meat slightly discolored and noticeable; color of casing has noticeably discolored contents.
1 point	Contents considerably discolored; color of casing has deeply penetrated contents.

b. Flavor score:

4 to 5 points	Contents have no abnormal odor and have a very good characteristic flavor and season.
3 points	Contents have no abnormal odor, flavor and seasoning generally satisfactory.

2 points	Contents have slightly raw or slightly scorched odor, flavor and seasoning somewhat inadequate.
1 point	Contents have a strong abnormal odor and a markedly poor flavor.

c. Texture score:

4 to 5 points	Contents have consistency and resilience; texture fairly smooth; practically no oil or liquid separation; small air spaces in contents.
3 points	Contents have consistency and resilience; texture fairly smooth; practically no oil or liquid separation; small air spaces in contents.
2 points	Contents lack consistency and resilience; texture less smooth; certain amount of oil and liquid separation has occurred; contents contain numerous small air spaces but relatively few large air spaces.
1 point	Contents have softened; considerable separation of oil and liquid; pack has become slimy and contents contain numerous large air spaces.

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PRODUCTS SEASONED WITH SOY BEAN SAUCE ("SHOYU")

I. Introduction

Products prepared by boiling in soy-bean sauce ("shoyu") are generally called "Tsukuda-ni", which is a specialty in Japan. Tsukuda is the name of place, where this product was invented. There are two types of "tsukuda-ni"; (1) "Tsukuda-ni" (in a narrow sense), and (2) "ame-ni" (boiled with soy-bean sauce and wheat gluten). These products are prepared by boiling small fish, meat of small mollusca, and cut pieces of big fish, with a seasoning solution made from soy-bean sauce ("shoyu") and sugar or wheat gluten for 60～90 minutes. Such products remains in edible condition for 20 days to one month unless molds grow on them. Their keeping quality is attributed to the penetration of soy-bean sauce ("shoyu") having NaCl into the marine products and to their partial dehydration.

In this connection, Hasegawa(1) has studied the increase and decrease of moisture content, NaCl, and sugar interchanged between raw baby clam meat and the seasoning solution as shown in Table 10-1.

Table 10-1. Increase and decrease in amount of moisture content, NaCl, and interchanged between raw baby clam meat and the seasoning solution

Boiling time (min.)	In baby clam meat			In seasoning solution		
	moisture-content	NaCl	sugar	moisture-content	NaCl	sugar
	%	%	%	%	%	%
0	73.09	0	0	39.04	10.39	36.37
5	43.41	3.80	7.10	43.36	10.30	32.62
10	34.41	4.84	12.58	38.92	10.29	38.59
15	29.54	6.37	16.19	33.26	13.01	40.53
20	25.19	6.40	16.19	30.04	11.44	43.17

The moisture content of the boiled baby clam meat decreased and that of NaCl and sugar increased.

Similar products prepared by boiling for a short time with "shoyu" and sugar, which in general are called "yamato-ni" have a keeping quality of only two to three days, because the degree of dehydration is not sufficient.

"Tsukuda-ni" is convenient to carry as a lunch item, is 100 percent edible. The product is sanitary, because the boiling is sufficient to destroy bacteria attached to the raw material. However, it has a defect in that the characteristic flavor and taste various kinds of raw materials are destroyed during the long boiling period. Production of "tsukuda-ni" is only about 8 % of all the amount of processed marine foods.

The production from 1964 to 1968 is shown in Table 10-2. The production increased after World War II until 1954, but recently it has decreased slightly. The cause of the decrease may be due to the following reasons: (1) the change of the taste for food by the younger generation in Japan: (2) popularizing of home electric refrigerators reduces the demand for non-perishable foods as in the past; (3) decrease of office workers or students carrying their own lunch; and (4) decrease of amount of raw material for "tsukuda-ni" owing their utilization for refrigerated food or for raw material of fish sausage. Accordingly the small entrepreneurs have changed to other businesses with the decreasing in demand. There were about 2,000 entrepreneurs in 1960. There are two kinds of manufacturers: (1) old shop style manufactures who mainly carry on a retail trade, (2) large entrepreneurs who deal wholesale. The former include manufacturers who catered especially to the high social circles, but the latter are manufacturers who prepare foods for daily consumption by the general public and are located in the neighbourhood of big cities.

Table 10-2. Production of "tsukuda-ni" from 1964 to 1968 (tons)

kind	1964	1965	1966	1967	1968
Laminaria "tsukuda-ni"	40, 782	40, 680	44, 661	45, 072	45, 931
Squid meat "tsukuda-ni"	15, 156	14, 132	14, 243	12, 285	10, 221
Others	49, 889	49, 968	74, 970	76, 783	54, 943
Total	105, 827	104, 780	133, 874	84, 140	111, 095

The places of production of "tsukuda-ni" may be classified into three groups according to the kinds of raw material.

(1) Places of production where raw fresh fish or mollusca are employed as raw material —— Akita, Aomori, Chiba, Ibaragi, Shiga, Kumamoto and Kanagawa Prefectures.

(2) Places of production where dried marine products (e. g., dried laminaria, dried squid, boiled-dried fish) are employed. —— Fukushima, Yamagata, Iwate, Nagano, Fukui, Wakayama, Kyoto, Osaka, Hyogo, Okayama, Hiroshima, Yamaguchi, Tokushima, Kagawa, Ehime, Kochi, Ōita, Miyazaki, and Kagoshima Prefectures.

(3) Places of production where raw fresh fish or mollusca and dried marine products are employed. —— Hokkaido, Miyagi, Tokyo, Niigata, Aichi, Shizuoka, Mie, Tottori, Fukuoka, Ishikawa, Toyama and Saga Prefectures.

The amount of "tsukuda-ni" prepared for the general public account for 60 % of the total production. The names of the commercial products of "tsukuda-ni" differ according to manufacturers or kinds of raw material. For example there is "Arakawa-ni" for which dried squid meat, and dried green peas are employed as raw materials, though the preparation is almost the same as "tsukuda-ni".

As raw materials, small fish (e. g., sand lance, *Ammodytes personatus*: "ami", *Neomusis intermedia* or *N. japonica*; small Prussian carp, *Cyprinus auratus*); shrimp; small shellfish, cut pieces of large fish meat (e. g., pieces of bonito meat), mollusca (e. g., baby clam), laminaria or seaweeds are employed. The preparation in almost the same in the various places of production.

II. General Procedures of "Tsukuda-ni"-Making

In the past, raw marine products were employed, but recently the dried materials (e. g., dried meat, dried laminaria, etc.) are also being employed. The preparation of a good quality products depends upon the quality of "shoyu" employed as they seasoning solution and proper boiling.

There are two boiling methods for the preparation of these products:

parching boiling ("iri-daki") and floating boiling ("ukashi-daki"). "Parching boiling" means that the raw materials (e. g., rehydrated dried squid meat or cod meat flour) are boiled with a small amount of seasoning solution in which the raw material is dipped. "Floating-boiling" means that raw materials are boiled floating in a relatively large volume of seasoning solution. This type of boiling is applied for many kinds of raw material. In floating-boiling it is important to regulate the strength of the fire, because the raw material employed for this boiling have various absorbing capacities according to their degree of dryness (moisture content of the raw material).

1. Parching-boiling method

This method of boiling is employed for the preparation of "tsukudani" from dried marine products, e. g., dried pond smelt, etc.

The boiling apparatus consists of several furnaces standing side by side, on each of which a flat pan of 60～80 cm in diameter is placed. This is a direct heating method. The construction is such that entire bottom of the pan is uniformly heated. Sometimes large pans are equipped with a stirrer to prevent scorching the material. Recently in order to boil a large quantity of raw material, double bottom cookers heated steam have been employed, or an electric rotating drum type boiling apparatus is employed.

The amount of raw material put into a big flat pan is 3. 8～10 kg at one time. If the amount is too much, the penetration of seasoning solution is not uniform. In boiling, a definite amount of prepared seasoning solution is put into the flat pan. When it has come to boil, the prepared raw material is put into the pan and it is continuously heated with stirring to prevent burning until the solution is absorbed. After the boiling, the product is taken rapidly out from the pan onto a cooling plate. For cooling, an electric fan is employed. Rapid cooling is necessary to impart a better luster on the product and to prevent deterioration due to the remaining heat.

2. Floating boiling method

The method is employed for raw fresh fish or mollusc meat. At first, the seasoning solution is poured into a big flat pan until it is 80 % full. When the solution has come to a boil, the raw material is put into the boiling solution. For the first 10~20 minutes it is boiled with a strong fire and then for an additional 40~60 minutes with a low fire. In this floating boiling method, the entire amount of the seasoning solution is not consumed, so some remains, which will be used again with the addition of new seasoning solution. The solution left over contains a large amount of tasty components dissolved from the fish as it is heated.

III. Preparation of Various Kinds of "Tsukuda-ni"

The kinds of "tsukuda-ni" are classified according to the raw material used: (1) laminaria, (2) squid meat, (3) small fish, (4) small shellfish meat, (5) small fresh-water fish, (6) shrimp, (7) "Ami" (*Neomysis intermedia*), (8) fish meat flour, (9) pieces of large fish and (10) seaweeds ("nori").

The preparation procedures are almost the same, therefore only the following six typical products will be described. (1) preparation from raw fresh materials: e. g., small shellfish meat, (2) preparation by parching-boiling method: e. g., dried squid meat cut in string or strip shapes, (3) preparation from seaweeds: e. g., laminaria, (4) preparation from dried marine products: e. g., dried small fish, (5) preparation from cubes of big fish meat: e. g., bonito or tuna meat, (6) preparation from fish meat flour.

1. **"Tsukuda-ni" of small shellfish meat (boiled small shellfish meat with "shoyu")**

The meat is separated from the shell by steaming or boiling raw fresh shellfish. For separating, a wire net drum is employed. The separated meat is put into the boiling seasoning solution in a flat pan. The seasoning solution is made in the proportion of 2 *l* of "shoyu", 750~840 g of sugar and 180~375 g of wheat gluten; the mixture is boiled down to 80 % of its original volume. This is called an "original seasoning solution". Into the flat pan (about 64 cm in diameter), 6~8 *l* of the "original seasoning solution" plus 1. 5~2 *l* of "shoyu" is placed and the solution is boiled. From 5.6 to 5.8 kg of the separated shellfish meat, 370~570 g of sugar, and 370 g of wheat gluten are added to the boiling seasoning solution and heated for about 30 minutes. When the shellfish meat is put into the pan, 180~375 g of ginger is also added. With the advance of the heating, when the meat becomes blackish brown, the heating is stopped and the meat is removed to cool on a cooling plate. The heating is done with a strong fire in the summer and with less intense fire from the autumn to winter. This procedure is employed as a means of controlling microorganisms in the summer.

For the preparation of "shigure-ni" of clam meat, which is a kind of "tsukuda-ni", "tamari-shoyu" (a kind of "shoyu" which is made from "koji" of soy-bean sauce and concentrated NaCl solution) is employed instead of ordinary "shoyu" (soy-bean sauce made from "koji" of wheat). The amount of sugar put in this products, a specialty in Mie Prefecture, is one half amount of that used for ordinary "tsukuda-ni".

2. "Tsukuda-ni" of squid meat

Dried squid meat ("surume") is cut into strings or strips and boiled with "shoyu". The tentacles and fins of dried squid are removed and the mantle cartilage (body) is skinned. In order to soften, the body is steamed or boiled slightly. After rough drying or roasting the steamed body, it is stretched to three times its original length with a roller. The extended body meat is cut into strings (3~4 cm × 0.12 cm) or strips (3~4 cm × 1 cm). These pieces of cut meat are parching-boiled. The seasoning solution is made from sugar 10 kg, wheat gluten 16 kg, salt 0.8 kg and water 10 *l*. The mixture is boiled to dissolve the ingredients. In order to obtain 3.75 kg of product, 2.6 kg of the seasoning solution and 1.8 kg of the squid meat are put into a flat pan and are boiled continuously with stirring for 20 minutes until the meat absorbs the seasoning solution. The seasoned meat is cooled on a cooling plate.

3. "Tsukuda-ni" of laminaria

Dried laminaria is cut into squares or strips. The sand attached to the pieces is shaken off. Then the pieces are washed for several minutes in fresh water containing dil. acetic acid and are drained on a bamboo basket. An amount of 9.4 kg of laminaria is put into 10 l of "shoyu" in a barrel over one night to absorb the solution. The laminaria which has absorbed the "shoyu" is put in a flat pan with 1.5 kg of sugar, and 7～37 g of caramel. At the beginning of the heating, the pan is heated with a strong fire to soften the materials. After the softening the heating is continued with a weak fire without burning the product. A final weight of 17 kg of the product will be obtained. Sometimes laminaria is boiled with small pieces of dried pasania mushrooms ("shii-take").

4. "Tsukuda-ni" of small fish

Dried small fish such as "ikanago" (sand lance, *Ammodytes personatus*), "wakasagi" (pond smelt, *Hypomesus olidus*) are employed as raw materials. The seasoning solution is made by boiling 2 l of water, in which 3 standard market size pieces of rectangular agar-agar, are added. Six l of seasoning solution is boiled in a flat pan, in which 4.9 kg of the softened dried small fish (which have been soaked in fresh-water for 5～6 hours) are parching-boiled for 10～15 minutes. A weight of 9.75 kg of product will be obtained. When floating-boiling is employed, 20 l of the seasoning solution is put into a flat pan and boiled. Into the boiling solution 5.6～7.5 kg of the softened small fish is added and the fish are floating-boiled for 10～15 minutes. After boiling, the fish bodies are taken out from the pan. The remaining solution is reused after adding new seasoning solution.

5. "Tsukuda-ni" of cubes of large fish meat ("kaku-ni")

As raw material, bonito or tuna meat is employed. The fish are beheaded and the bones and visceral mass are removed. The bodies are cut in 2 to 4 layers. The layers (fillets) are boiled and then the skin is removed. The fillets are roasted, and are then cut in cubes of 1～1.5 cm. The seasoning solution is made by mixing 3 l of "shoyu", 1.1 kg of sugar, 1 kg of wheat gluten, 5 g of coloring material and 10 g of agar-agar. The mixture is heated to boiling and the fish cubes are added and boiled for one hour. One hundred eighty grams of ginger is added to improve the tasts and flavor. The boiling is carried out carefully in order to retain the shape of the pieces.

6. **Tsukuda-ni" of fish meat flour ("denbu")**

The fish meat flour which is prepared from white flesh meat is called "soboro". The product prepared by boiling fish meat flour ("soboro") with seasoning solution is called "denbu". Fish meat flour ("soboro"), is prepared from fish, from which the scales, head, and visceral mass have been removed. The fish are then boiled and cooled after which the skin and small bones are removed. The meat is soaked in fresh water to remove fat and odorous substances. The meat is then pressed to remove excess water. The meat is then parching-boiled in a flat pan crushing it to a fibrous substance with a wooden spatula. This is "soboro".

The "soboro" (3. 75 kg) is seasoned with "shoyu" (4. 5 *l*), and sugar (3. 75 kg) in pan in which water (14. 5 *l*) is boiled. The boiling is carried out for 20～30 minutes. At last sweet Japanese "sake" (2. 2 *l*) is added to the seasoned fish meat flour, and the mixture is stirred sufficiently. Sometimes fish meat flour ("soboro") is mixed with soy-bean paste ("miso") and the mixture is seasoned with sugar and sweet "sake" or wheat gluten.

The "soboro" seasoned with soy-bean paste is called fish meat soy-bean paste ("gyo-miso"). The amount of soy-bean paste added is 3 times that of fish meat flour. Thus, this product consists mainly of soy-bean paste. The amount of sugar added is same as that of the fish meat flour ("denbu"). Therefore this product is considerably sweet.

IV. Inspection of Quality of "Tsukuda-ni"

"Tsukuda-ni" is produced in various Prefectures, so its quality is inspected and graded under the regulatory laws of the respective Prefecture. For example, "tsukuda-ni" of small fish such as sand lance, larval sardine fish, goby fish, pond smelt, shrimp, or squid meat, baby clam, laminaria or seaweeds ("nori") are inspected under the regulations of Hokkaido Prefecture. The factors inspected according to the regulation are color, flavor, shape, and absence of foreign matter. Here, the standards for general inspection of quality of "tsukuda-ni" will be noted.

1. Taste

According to the places of consumption, the degrees of saltiness or sweetness are different. But, the products of "tsukuda-ni" must have a characteristic sweet taste.

2. Flavor

It must have characteristic flavor and absence of moldy odor.

3. Color

As to small fish or shellfish meat, dark blackish color like that of "shoyu" having good quality is the best. As to "tsukuda-ni" of squid meat, a brilliant amber color; as to "tsukuda-ni" of fish meat flour, pink color is desired; and as to shrimp, a brilliant red is the best.

4. Shape

The shapes of the product is unique according to the respective kinds. For example, the small fish or molluscs in the product are the same size and are not deformed.

5. Foreign matter

There must be no foreign matter in the finished product.

6. Degree of boiling

"Tsukuda-ni" must be boiled well untill the seasoning solution penetrates throughly into the food and the dehydration must be well carried out. The moisture content of "tsukuda-ni" depends upon the degree of boiling, and its keeping quality depends upon its moisture content. Generally speaking, the moisture content in "tsukuda-ni" must less than 40 %.

V. Spoilage of "Tsukuda-ni"

The appearance of spoiled "tsukuda-ni" varies depending the kind of the product. The spoilage of tsukuda-ni" are found generally on the surface of the product, but seldom inner parts. The deteriorative damage found in laminaria, squid, and fish meat flour "tsukuda-ni", are usually caused by the action of molds. The main species detected in spoiled "tsukuda-ni" are *Aspergillus glaucus*, *Catenulatia* sp., and *Penicillium sp.*, *Aspergillus nigar*, *Rhizopus sp.* and *Mucor sp.* are often isolated from the deteriorated products.

If "tsukuda-ni" absorb water content of the product increase, there grow yeast on the surface of the product which result in evolution of an alcohol-like odor. The outbreak of this type of spoilage occurs in the products packed in a plastic film bag. If pasteurization of "tsukuda-ni" is insufficient, spoilage occurs rapidly during storing the product forming gas which makes the bag swell, and eventually the bag breaks. In this case, there are volatile acids or alcohols in the gas produced in the bag. These gases are produced with decomposition of the "tsukuda-ni" depending on the action of *Streptococcus sp.*, *Micrococcus sp.* or yeasts.

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FISH SCRAP (CAKE) AND FISH MEAL INDUSTRY

I. Introduction

Certain species of fish caught too abundantly to handle or waste materials from canning and fish or Japanese style fish paste operations are reduced to fish scrap or fish meal. For fish scrap the fish or waste materials are boiled, pressed and then dried by means of a dryer or in the sunshine. The fish scrap was utilized as fertilizer in the past. Fish meal prepared by crushing fish scrap to a fine powder has more recently been used as animal food. Fish meal is now being made directly from the raw fish bodies.

In the early days, the fish scrap was processed simply by boiling in a large flat caldron followed by pressing with a hand press and by drying in the sunshine. Such processes are still carried out in few place in Japan. But recently in order to utilize the waste from canning or fish sausage processing, large entrepreneurs have built complete reduction plants similar to those in Europe and America.

Generally speaking, the processes of making fish meal or fish scrap can be divided into two types: wet- and dry- reduction processes. The former is used in utilizing the dried meat attached to the back bone from Japanese style dried herring ("migaki-nishin"), the head from freeze-dried Alaska pollack or latter type process is used in utilizing fish caught too abundantly to handle, in obtaining oil and meal, or in utilizing waste materials from canning, fish sausage or Japanese style fish paste processing.

In the dry-reduction process, the dried meat attached to the back ("do-nishin") bone of dried herring ("migaki-nishin") is first put through a grinder. This serves to break up the large pieces and to disintegrate the bone. This material is then loaded into a dryer, or spread on straw mats. The fish cake prepared by the dry-reduction process in the sunshine is used as fertilizer; the same product prepared by dryer and crushed to powder is used as animal food for poultry and pigs.

The wet-reduction process consists of boiling and pressing fish bodies or the waste materials before drying. The oil separates during boiling and dehydration is made easy. Oil and water are separated from the meat by pressing. These processes are carried on separately or continuously. The apparatus for continuous treatment requires large capital, therefore such processes are carried out at fish landing places by large fishing companies or on floating factories. According to Japanese Governmental Regulation, exported commercial fish meal is divided into several categories by the species by the species of fish used: white fish meal, common fish meal, brown fish meal, mixed fish meal and whale meal. White fish meal is prepared from white flesh fish, such as cod, Alaska pollack or flat fish. Common fish meal (orange grey or brown color) is prepared from light red flesh fish such as Atka mackerel. Brown fish meal (orange yellow or brown) is prepared from red flesh fish such as sardine and herring. Mixed fish meal is prepared from the mixture of white flesh fish and red flesh fish, but dark brown and deep black are not included in this group. Whale meal is prepared from whale red meat.

II. Production of Fish Meal and Fish Scrap

Statistics on the production of fish meal and fish scrap are presented in Table 11-1～3.

Table 11-1. Production of fish meal and fish scrap prior to World War II (tons)

	1933	1934	1935
Sardine meal prepared from fish scrap	339,075	3,977,025	3,990,300
Herring meal prepared from fish scrap	100,496	106,763	51,761
Cod, Alaske pollack meal prepared from fish scrap	5,910	4,946	3,231
Flat fish meal prepared from fish scrap	2,404	1,553	1,646
Whale meal	3,004	2,543	9,675
Fish scrap from sardine	21,675	19,943	21,279
Fish scrap from dried herring	36,319	32,044	22,279
Fish scrap from waste materials	9,994	14,816	15,000
Others	53,528	88,148	71,130
Total	572,405	4,247,781	4,188,873

Table 11-2. Production of fish meal and fish scrap after the World War II

	1952	1953	1954
Sardine meal prepared from fish scrap	8,070	11,888	7,661
Herring meal prepared from fish scrap	21,233	13,159	1,680
Fish scrap from sardine	1,864	1,665	506
Fish scrap from waste materials	22,170	27,458	35,786
Other	41,963	41,468	38,816
Total	95,300	95,638	84,449

Table 11-3. Recent production of fish meal and fish scrap

	1965	1966	1967	1968
Fish scrap from sardines	3,181	2,960	1,267	803
Fish scrap from herring	58	83	86	81
Fish scrap from other fish	18,420	15,585	20,492	24,983
Fish scrap from saury	2,334	2,567	4,910	2,249
Fish scrap from mackerel	—	—	—	10,601
Fish scrap from waste	88,412	109,101	113,823	133,030
Fish meal (including various kinds of fish)	181,564	177,015	176,125	207,122
Aquatic mammals scrap	3,435	6,297	5,021	5,957
Others	76,508	73,571	82,286	139,632
Total	373,965	387,184	404,014	524,463

Before the war the annual average amount of production of fish meal and fish cake came to two-thirds of the total amount of the catch. The amount of fish scrap prepared from waste materials was less than that after the war. The amount of fish meal and scrap after the war decreased remarkable from that prior to the war. The cause of the decrease of the production of fish scrap and fish meal is mainly the decrease of the catch of sardines and herring. On the other hand, almost the entire amount of the fish catch has been processed to food. However, the catch of mackerel and saury increased after the war, some of which is prepared into fish meal or cake owing to the quantity being too great to handle as food. After the war the production of fish cake prepared from the waste materials increased from the view point of the desirability of complete utilization, owing to the decrease of the catch.

III. Dry-Reduction Products

The dry-reduction products are fish scrap from sardines, or from meat attached to the back bone of dried herring ("migaki-nishin"), from milt of herring or fish paste operations. Such fish scrap products are used as fertilizer. The fish scrap from sardine ("hoshika") is a primitive product for which sardines are simply dried at the sea shore in the sunshine. The milt or gills of herring are also dried in the sunshine. Seaweeds, fish scales or carapace of crab are also dried simply in the sun for use as fertilizer.

IV. Simple Process for Making Wet-Reduction Products

The products made by the simple process of wet-reduction are fish cakes prepared by boiling and drying fish bodies which are caught too abundantly to handle at once, such as sardines, herring or saury, flat fish, and whale meat. The fish cake prepared from fish bodies by boiling, pressing and drying is called "shime-kasu". The waste materials from canning, fish sausage or Japanese style fish paste operations are also boiled and dried to prepare fish cake. This is called "ara-kasu". The "ara-kasu" is prepared from the waste materials from various species of fish, such as salmon, tuna, bonito, cod, Alaska pollack, and shark.

The process for the preparation of fish cake consists of boiling, pressing and drying. By boiling, a part of the oil and body fluid is separated from the fish bodies. By pressing, the greater part of such fluids is separated to leave a solid block of fish meat. By drying, the crushed cake is dehydrated. Nowadays the fish scrap dried by a dryer is further crushed to fine powder. This is used as animal food.

1. Raw material

Raw material used for fish cake from fish bodies must be fat and fresh. If unfresh raw material is used the meat becomes soft, the cells deform owing to autolysis and spoilage, and the meat tissue becomes deformed and does not coagulate during boiling. The boiling water becomes turbid and the oil separated becomes an emulsion difficult to separate from water. The yield of the product decreases and its quality becomes inferior.

2. Boiling

The caldron is flat with a diameter of 0.9~1.4 m and a depth of 60~90 cm. The volume of boiling water is 36~144 *l* and the amount of raw material dumped in is 225~262 kg. The fire box (furnace) was planned to pass the fire uniformly across the bottom of the caldron. One which was designed by the Hokkaido Fisheries Experimental Station is of the one-way fire style; it requires one-half the time to boil water and half as much fuel as the old style furnace.

Fresh water is used for boiling. If sea water is employed, moisture, ash, fat and NaCl content are increased in the finished product; on the contrary the amounts of nitrogen and phosphorous contents which are effective as fertilizing components, are decreased. If the product contains a large quantity of NaCl, it is hygroscopic, and molds grow easily. If the product contains a large quantity of fat, it oxidizes easily becoming yellowish brown in color.

3. Pressing

After complete boiling, the boiled fish bodies or waste materials are pressed in a vertical cylinder. The pressed block is called "tama-kasu". There are many kinds of hand-presses. Recently the use of such presses has declined and hydraulic presses are now used. If the pressure is insufficient, large amounts of water and oil will remain, and the drying will be delayed; contrarily, if the pressure is too great, the quality of the product becomes inferior owing to the deformation of the tissue. The pressing must be done while the boiled fish bodies are hot.

4. Drying

Fish blocks ("tama-kasu") which were obtained by the pressing are crushed with a large wooden spatula, and the crushed material is spread on straw mats to dry in fine weather. If the weather is bad, the fish blocks are kept in a store house until the weather clears up; flies must be kept away. After the fish cakes are dried for a day, they are piled in the storage place to equalize their moisture content over night. The next morning the drying is continued. The finished products are packed in straw bags. Today the drying is often carried out in a dryer of the large tube type heated with steam or with hot air from a coal or oil heater.

V. Improved Process for Wet-Reduction Products

Sun-drying depends on the weather. Almost all the entrepreneurs having sufficient capital have installed dryer in their shore land factories which are large horizontal tube types heated by steam or hot gas. This type of dryer is composed of a furnace in which the heat is generated and hot gases are forced through a cylinder which extends from the furnace. The diameter of these cylinders varies from 1 to 2 meters and the length from 10 to 15 meters. They are mounted on trunnion rings and slowly rotated. Inside the cylinders are fixed fins or plates which carry the fish scrap up toward the top and then spill them back through the hot gases passing through the cylinder. The wet fish scrap enter the cylinder near the furnace, and the rotation of cylinder and fins gradually work the fish scrap towards the opposite or discharge of dryer. In many cases, the fish cakes dried by those dryers are crushed by a crusher to make fish meal. A few entrepreneurs have employed oil furnaces and caldron, but almost all of them have recently installed continuous live steam cookers and continuous screw presses. Fish scrap-making equipment has been recently changed to a series of machines (continuous live steam cooker, continuous screw press, continuous cylindrical dryer (horizontal large tube type) and crusher). The quality of fish scrap (or fish meal prepared from fish scrap) made by these methods has been improved. Therefore the production of fish scraps has decreased and the amount of fish meal has increased.

Fish meal processed by the simple process of wet-reduction (boiling in caldron pressing in vertical cylinder or hydraulic press, drying in the sunshine and then crushing) is called "sun-dried fish meal". Fish meal processed by the improved processed by the improved process of wet reduction (boiling in caldron, pressing in vertical cylinder or hydraulic press, drying in dryers and crushing) is called "dryer-dried fish meal".

VI. Process for Making Fish Meal on Floating Factories

There are two kinds of floating factories on which fish meal is processed: one kind is the floating fish meal factory, on which fish meal only is processed from fish bodies which are caught abundantly, the other is the floating cannery, on which the waste materials from canning are processed to fish meal. Those floating factories are operated by the large fishing corporations in Japan. Fish meal which has been processed by a series of machines (continuous live steam cooker, screw press, dryer and crusher from raw fresh fish or raw waste materials from canning on floating factories) is called "mechanically-processed fish meal".

Sometimes fish meal is named according to the species of fish: for example, sardine meal, cod meal, herring meal, etc. In Japan, many of the fish meal plants installed on floating canneries are made by Japanese iron works (e. g., Ohno Kagaku Kikai Co.). These fish meal plants consist of a continuous live steam cooker, continuous screw press, continuous rotary dryer and crusher. Many of machines are similar to those employed in Europe or America. The construction details of such machines are well known and need not be described here. When the dried meal is discharged from the dryer, it is spread over the floor to cool before packaging in double-wall paper bags, with an asphalt binder between the walls. The quality of fish meal processed on floating factories is good, because the raw material is very fresh.

VII. Inspection of Fish Meal for Export

When Japanese fish meal is exported, its quality is inspected by Governmental Regulation, which is as shown below. For domestic uses, fish meal or fish scrap are inspected by the respective Prefectural authorities under the Regulation of the Japanese Ministry of Agriculture and Forestry. The factors inspected on material for domestic use are almost the same as those for the exported product.

Table 11-4. Japanese Quality Standards and Inspection Procedure for Export Fish meal and Fish scrap under Export Inspection Law of 1957 (Revised on 20th June, 1959)

Name / Factor	Common Fish meal	White Fish meal	Brown Fish meal	Fish meal Mixed	Whale Meat Meal	Fish scrap
Color	Orange Grey or Brown	Grey or Yellowish Grey	Orange Yellow or Brown	Dark brown and deep black are not permitted	Deep black is not permitted	Dark brown and deep black are not permitted
Crude Protein	50.0 % min.	50.0 % min. (45 % min., in case of being made of fish residue scrap)	50.0 % min.	45.0 % min.	70.0 % min.	50.0 % min.
Phosphoric Acid (As P_2O_5)	4.0 % min.	50.0 % min. (6.0 % min., in case of meal containing less than 50.0 % crude protein)	4.0 % min.	5.0 % min.	3.0 % max.	3.0 % min.
Moisture	12.0 % max.	12.0 % max. (13.0 % max. for flocky fish meal)	11.0 % max.	12.0 % max.	10.0 % max.	12.0 % max.
Crude Fat	11.0 % max.	9.0 % max. (7.0 % max., in case of meal containing less than 50.0 % crude protein)	12.0 % max.	12.0 % max.	12.0 % max.	12.0 % max.
Salt	3.0 % max.	3.0 % max.	3.0 % max.	3.0 % max.	3.0 % max.	—
Sand	3.0 % max.	3.0 % max.	3.0 % max.	3.0 % max.	1.0 % max.	3.0 % max.
Impurities	To be free from straws, shells, bone- and meat-meals of mammals and other impurities.				To be free from	Same as with the

		straws. shells, bone meals and other impurities	case of fish meal
Form	Not to be caky.		No form requirements
Particle	The size of the particles shall be uniform and passable mesh of 2.5 mm. Flocky meal and fish scrap are not restricted.		
Mold	None permitted.		
Odor	Smell of ammonia, scorching smell or other bad odor are not permitted.		
Worm	Not to be infested with injurious worms.		

1. **Japanese Quality Standards for exported fish meal and fish scrap** (Table 11-4)

2. **Method of Analysis**

(1) Crude Protein: The amount of nitrogen will be determined by the Kjeldahl method, and the volume of nitrogen multiplied by 6.25 will be regarded as the amount of crude protein.

(2) Phosphoric acid: This shall be determined by the volumetric molybdate method.

(3) Moisture: Put 2 g of prepared sample in tared weighing tube (4.5 cm in diameter and 33 cm in height), and dry in electric oven for 5 hours at 100° C. Cover weighing tube, cool in desiccator for 1 hour, and weigh. Then the decrease of the weight will be moisture.

(4) Crude fat: Put 5 g of prepared sample and predry for 1 hour at 100° C. Extract crude fat by Soxhlet apparatus using dried-ethyl-ether for 12 hours. Then dry the extract for 2 hours at 100° C., cool in desiccator for 1 hour, and weigh.

(5) Salt: Put 10 g of prepared sample, add 100 g of distilled water and potassium ferrocyanide and zinc acetate. Shake for 20 minutes and to let stand 1 hour. Then, take a 50 ml. of aliquot from the upper-clear

part, add potassium chromate as an indicator and titrate with 0.1-N silver nitrate. Thus salt will be determined.

(6) Sand: Put 5 g of prepared sample and burn to ash, then transfer the ash into beaker with 50 ml. of 10 % hydrochloric acid, and boil it for some 20 minutes. Filter the contents of the beaker through quantitative filterpaper. Wash it well with distilled water, then dry and burn.

3. Packing Requirements

To be packed in good jute bags or in paper bags of fiveply kraft paper (under Japanese Industrial Standard P-3401 in 1658), or in bags better than the fomer ones. No packing requirements in case of fish scraps.

4. Sampling Procedure

Sampling shall be made at random at the under-specified sampling rates.

Table 11-5. Sampling rates

Lot Size (Bags)	Sampling Size (Bags)
Less than 31	All
31 ～ 400	30
401 ～ 1,000	60
More than 1,000	100

5. Marking for Passed Meal

Legal marks shall be stamped on the bags by the Government inspector.

Colors of the marks are as follows.

Common Fish meal:	Blue
White Fish meal:	Green
Brown Fish meal:	Red
Fishmeal Mixed & Fish scrap:	Black
Whale Meat Meal:	Purple

VIII. Inspection of Fish Meal for Domestic Consumption

The quality of fish meal for domestic consumption is also inspected by a local regulation based on Governmental Regulation for export. Therefore, quality standard and method of analysis of fish meal for domestic used is similar as those of exported fish meal and fish scrap.

For the analysis of crude fat, official method based on Soxhlet's extraction method is rather complicated, because the method requires comparatively long extraction time and particular apparatus. Motohiro et al.(1) have developed a simple and rapid method of estimating the amount of oil in fish scrap for fertilizer. The oil is extracted with acetone and is separated from acetone with saturated potassium chloride solution. In comparing the Soxhlet's method with this method, the advantage of the latter are a simplified procedure and shortened time for estimation, so that it is possible to test many different samples within a limited period. This method is able to determine a relatively wide range of oil contents (6～26 %) in different samples.

An outline procedure of this method is as follows: Weigh 10 g of sample by crude balance. Put the weighed sample into a flask of 50 ml volume, add 20 ml of acetone in it, extract oil for 20 minutes by shaking. After extracting the oil, leave for 2～3 minutes the flask until the particles deposit on the bottom. Ten *ml* of the acetone from the flask are added to a glass cylinder, then add 21～23 *ml* of saturated potassium chloride until the oil comes on the upper layer of the mixture, and measure the amount of oil. In the case, a difficulty concerns to separate oil and potassium chloride solution, to warm the mixture for a few minute on a water bath is available.

IX. Comparison of Qualities of Fish Meal processed by Various Methods

The chemical composition and quality of fish scrap or fish meal depend upon the species of fish, its freshness, the processing method, and conditions. Oshima's observations(2) on this subject are summarized.

(1) Except for fat and moisture content there is but little difference

in the chemical composition of raw fish of different species. The fat content of the fish scrap or fish meal differs significantly according to the species of raw fish used. If fish of low fat content or white flesh, such as cod or Alaska pollack are used the product is whitish in color and has a low fat content. On the other hand, if fish of high fat content or red flesh fish are processed products become brown unless a defatting procedure is employed.

(2) The chemical composition in the fish scrap or fish meal differs between those products prepared from the whole fish bodies or from the waste materials from canning or fish sausage operations. Waste materials contain a larger volume of bones than there are in the whole fish bodies; accordingly products made from the former have a larger amount of calcium phosphate and has less protein than those made from whole fish.

(3) Even if the same species of fish is employed as the raw material for fish cake or fish meal, the product from small sized fish contains a larger amount of clacium phosphate from large sized fish. The amounts of protein and fat are the opposite.

(4) If the freshness of the raw fish is low or if the raw fish meat spoils during the drying process, the fat content of finished products is higher. Especially in the case of sun-drying, if half-finished product is exposed to rain, the amount of ammonia in the finished product is greater than in that prepared from unfresh raw fish. Fish scrap or fish meal prepared by sun-drying has a higher moisture, sand and ammonia content than that prepared by a direct-heat dryer. However, latter is darker in color and less digestible than the fomer. The difference in fat content between the two is slight. The quality of fish meal (mechanically processed fish meal) prepared from raw fish by a fish meal-making plant is the best.

(5) The fat in fish scrap processed by sun-drying or stored for a prolonged time is easily oxidized to ether-insoluble matter by atmosphere oxygen. This ether soluble material is dissolved by benzol of acetone.

(6) The fat content of fish scrap depends on the species of raw material and the degree of boiling to which it is subjected during prepartion and processing. The chemical composition of Japanese fish scrap

or fish meal made from fish scrap is shown in Tables 11-6 and 7.(2)

Table 11-6. Maximum and minimum chemical composition of Japanese fish scrap (%)

	Moisture-content	Crude protein(total amount of nitrogen)	Crude fat	Calcium phosphate (phosphoric acid)	NaCl	Sand	Ammonia	Digestibility
Maximum amount	16.0	75.0 (12.0)	20.0	25.0 (12.5)	5.0	10.0	0.300	93.0
Minimum amount	5.0	40.0 (6.4)	2.0	5.0 (2.5)	0.3	0.2	0.003	70.0

Table 11-7. Average chemical composition of various kinds of Japanese fish scrap (%)

	Moisture-content	Crude protein (total amount of N)	Crude fat
Fish scrap from herring	12.0	62.0 (9.9)	13.0
Fish scrap from sardine	15.0	50.0 (8.0)	15.0
Fish meal crushed from herring fish cake	11.0	55.0 (8.8)	9.0
Fish scrap from saury	10.0	55.0 (8.8)	9.0
Fish scrap from Atka mackerel	12.0	48.1 (7.5)	5.0
Fish scrap from waste materials from dried herring	11.0	58.8 (9.4)	16.0
Fish scrap from waste materials from dried Alaska pollack	11.5	58.5 (9.2)	14.0

	Calcium phosphate (phosphoric acid)	Sand	Ammonia	Digestibility
Fish scrap from herring	10.0 (5.0)	3.0		

Fish scrap from sardine	12.0 (6.0)	1.0	0.04	85.0
Fish meal crushed from herring fish cake	13.0 (6.5)	4.0		
Fish scrap from saury	13.0 (6.5)	2.0		
Fish scrap from Atka mackerel	20.0 (10.0)	4.5		
Fish scrap from waste materials from dried herring	9.0 (4.5)	2.0		
Fish scrap from waste materials from dried Alaska pollack	6.4 (3.2)	1.2		88.0

X. Use of Fish Meal as Animal Food in Japan

In the past, fish scrap was used as fertilizer. At present almost the entire production is being used as animal food. However, a small amount of fish scrap is used as fertilizer, for example, fish cake prepared crab carapace or from "shio-mushi" (*Tecticeps japonicus*) or same waste materials from dried herring meat preparation.

Recently the production process has been improved as above described. Almost all the factories have installed a part of or a complete fish meal making apparatus. The product thus prepared is of good quality and its use is up graded from fertilizer to animal food.

It is important to take care in making fish meal for animal food. First, attention should be paid to the freshness of raw material. If animals eat fish meal prepared from unfresh raw material, they may suffer from food poisoning. The finished products should have low moisture content in order to prevent microbial spoilage. The finished products should contain only small amounts of volatile basic nitrogen (ammonia and amines), fat and sand. The presence of any large amount of volatile basic nitrogen indicates decomposition which might be attributed to the use of unfresh raw material.

By the use of dryer after the war II, the quality of fish meal has improved greatly.(3) For example, as shown in Table 11-8, digestibility of the fish meal is higher in the product prepared by dryer than that

Table 11-8. Digestibility of fish meal (%)

Raw material	Whole meal		Scrap meal		Scrap meal
	Indirect drying	Direct drying	Indirect drying	Direct drying	Sun drying
White flesh fish	96	96	—	92	83～92
Dark flesh fish	97	91～95	95	92	87～90
Unknown (imported)					88～90

prepared by sun-drying.

Recently many big fishing companies have tried to engage in "land operations" which includes raising chickens, pigs or cattle on fish meal prepared on their own floating canneries or floating fish meal factories. The feed value of these products has been studied and the results may be summarized as follows.

Effects on chickens: Protein and calcium phosphate in fish meal are suitable for brood or adult chickens. From long ago, fish cake prepared from waste material from dried herring meat ("migaki-nishin") has been said to be the best food for chickens. That may be due to the fact that the fish cake contains large amounts of calcium phosphate and vitamin D. Fish meals in the proportion of one-third of the total amount of feed for poultry is said to be optimum.

Effects on pigs: Fish meal has similar effects upon pigs as upon poultry. It is effective in preventing osteomalacia. However, because the oil tends to import a fish-like odor to pork meat, meal of low fat content should be used for this purpose. The amount of fish meal to be fed to pigs is optimum at 10～15 % of the total amount of feed.

Effects on cows: Fish meal has similar effect on cows as on pigs. In this case, too, non-oily fish meal should be used. The proper amount is considered to be 5～10 % of the total amount of feed.

XI. Preparation of Squid Meat

Squid (*Ommastrephes sloani pacificus*) is caught abundantly in Hokkaido, Japan. The catch was 383, 390 tons in 1955. For the most part squid has been prepared as dried squid ("surume"). Recently

Shudo et al(4) have tried to prepare fish meal from squid. The process will be described here. Squid, from which visceral mass was removed, is put in boiling water in a large caldron. After boiling for a short time, the squid is taken from the caldron, and dried on straw mats in the sunshine. The dried squid is crushed to powder. The yield is about 15 % of the raw material. The fresher the raw squid the greater the yield of dried meal. The chemical composition of squid meal include total nitrogen 12 % (crude protein is 85 %), moisture content 12 %, crude fat 2 %, and phosphoric acid 1.5 %. The composition is similar to that of other fish meal except that it has a higher nitrogen and lower calcium phosphate content. Squid meal is used for animal food. However, it can not be exported, because its calcium phosphate content is less than the amount required under Japanese Governmental Standards for exported fish meal.

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FISH SOLUBLES INDUSTRY

I. Introduction

The liquid fraction which passes through the screen of the press during the processing of fish meal or fish scrap contains water with some soluble proteins, oil, and suspended protein. These materials are separated by various types of filters. This liquor is either placed in settling tanks for gravity separation of the oil or put through a centrifuge system for the separation of the oil and water fractions. The water fraction from the above separations is called "stick-water". This liquor contains minerals, vitamins, amino acids, and many other valuable nutritional factors. The "stick-water" from the meal and oil separation is collected in a receiving tank. It is then held at 60°~70° C for 30 minutes to complete the coagulation of the proteins and the precipitation of enzymes. Next the precipitated solids are separated by a clarifying centrifuge. This "stick-water" is then concentrated by means of vacuum evaporators. The condensed "stick-water" which has reached a predetermined concentration is used by dry-feed mixers for inclusion in mixed animal foods. It is called "fish solubles". The moisture content is such that it is readily absorbed such feed material as wheat middlings.

II. Fish Solubles Industry in Japan

In Japan fish solubles are prepared in the course of the processing of fish meal or fish scrap on the floating fish meal factories or floating canneries. Some land factories devote themselves to the preparation of fish solubles only from press water or visceral mass. That is to say, on the floating fish meal factories press water from certain species of fish (cod, Alaska pollack, flat fish) boiled for preparation of fish meal in the continuous cooker, is separated and is digested by means of an autolytic enzyme or pharmaceutical protease, and then is filtered and condensed. On the floating canneries press water from the waste materials boiled for the preparation of fish scrap is utilized. In the land-"fish soluble" factories, the press water or visceral mass is collected by motor trucks. The pressed water is digested by enzymes. The visceral mass is kept at moderate temperature and optimum pH to accelerate the autolytic action of visceral mass to digest the material. The digested solution is filtered and condensed. In Japan there are several floating fish meal factories, and 11 floating canneries equipped with apparatus for fish meal and fish solubles preparation. There also some large factories which specialize in manufacturing "fish solubles" as well as other land canneries or marine food factories, equipped to make fish cake and fish solubles. In one of big fish solubles land factories, the Nippon Kagaku Shiryo Co. (Japan Chemical Fodder Co. Hakodate, Hokkaido) has processed fish solubles from press water derived from the processing of fish and especially from squid visceral mass. These fish solubles are absorbed on rice bran or wheat bran and sold under the commercial trade name "S. P. fodder".

III. Processing of "S. P. Fodder"

1. Process

Visceral mass removed in the processing of dried squid ("surme") is utilized to prepare squid oil and fish soluble.

The proteolytic action of squid visceral mass, especially of the liver, is very active; the liver comprises the greater part of the visceral mass. The visceral mass collected by truck cars is put in a tank without added water and autolyzed at 55° C for about 10~12 hours to liquefy completely. The liquefied visceral mass is heated with a small amount of added cold water. The liquid is passed through a centrifuge system to separate the oil. The water left from the oil separation is condensed by a vacuum evaporator to a predetermined concentration. The condensed stick water (this is "fish solubles") is mixed with wheat bran, and the mixture is dried by means of a large rotary tube type dryer.

2. Chemical composition of "S. P. fodder"

The chemical composition of "S. P. fodder" is as follows: moisture 12 %, crude protein more than 32 %, crude fat more than 7 %, crude fiber less than 7 %, ash less than 7 %, soluble non-nitrogeneous substance more than 30 %. The amount of amino acid nitrogen in relation to the total amount of nitrogen is as follows: alanine 6.6 %, arginine 9.5 %, aspartic acid 5.4 %, cystine 1.6 %, glycine 3.6 %, glutamic acid 3.2 %, histidine 3.9 %, leucine and isoleucine 9.2 %, lysine 4.3 %, methionine 3.4 %, phenylalanine 3.7 %, serine 4.8 %, threonine 2.7 %, tyrosine 2.7 %, valine 5.1 %. The amounts of vitamins contained are as follows: B_1 (thiamine) 5.5 (*r*/g), B_2 (riboflavine) 33.5 (*r*/g), B_6 (pyridoxine) 53.9 (*r*/g), B_{12} 1.8 (*r*/g), niacin 44.6 (*r*/g), choline 66 mg/g. The amounts of minerals are as follows: phosphorus 0.54 %, potassium 1.28 %, calcium 0.37 %, manganese 0.018 %, iron 0.014 %, copper 0.14 %, chlorine 0.26 %, iodine is trace.

The autolyzed and liquefied solution from unfresh squid visceral mass is separately led to a settling pond filled with sand. The sediment on the surface of the sand is sun dried. The dried matter (this is called "uro-kasu") is fertilizer after mixing with the waste materials of tobacco and drying. The chemical composition of this fertilizer is as follows: total amount of nitrogen 6.0 %, potassium 2.5 %, and phosphorus 1.0 %.

The production of "S. P. fodder', and fertilizer (squid-"uro-kasu") in comparison with the total catch of squid, prepared dried squid ("surume") and squid oil produced in southern Hokkaido are shown in Table 12-1.

Table 12-1. The production of squid, oil, "S. P. fodder", and fertilizer (squid-"uro-kasu") (tons)

	Total amount of catch	Dried squid	Squid oil	S.P.fodder	Fertilizer (squid-"uro-kasu")
1952	230,625	173,512.5	4,400	450	450
1953	172,575	157,515	7,938	1,850	1,650
1954	237,252.5	199,650	4,926	2,800	480
1955	200,662.5	182,962.5	4,572	4,300	500
1961	383,993	26,947	2,967	553	270
1962	536,470	31,258	3,181	1,453	490

If the entire amount of visceral mass (18 % for raw squid) is utilized to prepare squid-"S. P. fodder", the amount of production could be further increased.

3. Use of squid "fish solubles" as animal feed or fertilizer.

The effects of "S. P. fodder" on animals have been studied by various investigators and its value for cattle and poultry has been demonstrated. The squid "uro-kasu" is an efficient fertilizer for rice-plants and it is as fish scrap or ammonium sulphate.

IV. Processing of Fish Solubles on Floating Factories

On floating canneries, press water from the waste materials (head, tail, fins) prepared for fish cake or the visceral mass are utilized to make "fish solubles". The "fish solubles" plants installed on the floating canneries are of a small type. On floating fish meal factories, press water from raw fish prepared for fish meal is utilized to make "fish solubles". The apparatus installed on those is of a large scale. The apparatus installed on both types of factories consists of a digestion tank, vibrating screen or some other type filter, centrifuge system, and vacuum evaporator. On floating factories, the press water or visceral mass is first digested by pharmaceutical protease added at about 0.2 % of the weight of raw liver. The protease preparation "Bioprase" (commercial name, Nagase Industrial Co. Osaka) is made from *Bac. subtilis.* The use of pharmaceutical protease accelerates digestion.

The type and capacity of apparatus on floating factories are similar to those used in the U. S. A. and Europe. The operation is also similar.

V. Fish Malodor Problem from Fish Meal and Fish-Solubles plants

The manufacture of fishmeal, oil and fish-solubles has long been regarded as a socially offensive trade and despite the many advances that have been made by way of improved techniques and restrictive legislation there still remain many instances where the operations of this important industry offened people in the vicinity of the factories. The malodor responsible for this situation can arise from a variety of sources, among which are the pits in which the raw material is collected and held for processing, the stream escaping from cookers, presses, centrifuges and evaporators; debris on elevators and conveyors belts and in empty drums; and stored product.(2)

These are unlikely to cause more than very local offense, mostly within the confines of the factory, and are manageable by general good housekeeping, efficient design and maintenance of plant and control of the staleness and time of holding of raw material. None of them gives rise to problems comparable in magnitude with that of the vapor effluent from the driers, and it is accordingly at this point that attention has been focused. The most common form of drier in Japan is the oil-burner direct flame type. In this drier the temperature involved are higher than 150° C, and leaves sufficiently odorants including ammoniacal-type volatiles and water vapor from the raw material.

Motohiro and Terachi(3) have found that the odorant consists of ammonia, trimethylamine, hydrogen sulfide and volatile fatty acids. Out of them, those of small amount disappeared and the degree of odor intensity reduced logarithmically as the distance receded from the factory. The data contributed to the calculation of an effective height of the exhaust stock of the drier. The effective height can be calculated from the following equation:

$$C = 2.8 \times 10^{-3} F_1(h/H)/UX\Theta h$$

where, U is average velocity of wind (m/sec); X is distance of the lee side (km); Θ is diffusion angle of odorants in crossways (°); h is diffused height of odorous gas (m); H is effective height (m); and F_1 (h/H) is the factor. The effective height should be higher than 20 m by a consideration of the meteorological condition.

A water scrubing has been thought to be effective for removal of the odorants dissolving soluble effluents. However, the volume of water is related to the ratio of removal of the offensive odor from a water scrubber. Motohiro and Kato(4) have made an experiment to determine a relation between the effective volume of water to the different amount of the malodorous gas, and the following equation was derived from it:

$$y = 7.4\, z^{-0.58}\, e^{-4z-0.76x}$$

where, y is odor concentration; z is the amount of the malodorous gas, and x is the volume of water. According to the equation, it might be impossible to deodorize a water scrubber thoroughly even if a large volume of water is used for washing. The asbestos-cement sheets placed in the water scrubber results in the decrease of the odor concentration of the gas.

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FISH OIL INDUSTRY

I. Introduction

"Aquatic animal oil" includes fish oil, aquatic animal oil and liver oil. Fish oil is that obtained from certain species of fish or the waste materials from the processing of fish. The name of the fish oil varies according to the species of the raw material. For example, sardine oil, herring oil, etc. If the species of original fish is unknown after the production, it is called miscellaneous fish oil.

Fish oil is produced on floating meal factories, floating canneries or in land fish meal factories. Aquatic animal oil is oil from aquatic mammals such as whale or dolphin. It is named according to its origin, e.g., whale oil or dolphin oil. Aquatic animal oil is produced on whale factory ships or in land whale factories at shore station. "Liver oil" is oil from the liver of various aquatic mammals or fish. The crude liver oil is produced in land factories, to which whale liver or fish liver are brought and heated to make liver oil. The crude liver oil is purified in special factories near cities. Data on the production of marine oils are shown in Tables 13-1, 13-2 and 13-3.

Table 13-1. Production of fish oil at land factory (tons)

	Total(include liver and visceral oils)	Sardine oil	Herring oil	Atka mackerel oil	Saury oil	Flat fish oil	Mackerel oil	Other
1964	27,730	117	1	1,031	2,892	46	—	6,071
1965	40,737	439	5	517	2,132	69	—	15,146
1966	42,502	450	0	137	2,009	203	—	16,183
1967	46,588	249	2	209	1,926	440	—	13,791
1968	56,337	15	6	86	531	84	11,935	13,048

II. Raw Materials of Fish Oil

In the Regulations of the Japanese Ministry of Agriculture and Forestry, fish oil is defined as that oil produced from spring herring, small herring, summer herring, sardine, Atka mackerel, oily plaice, plaice, mackerel, saury and other fishes, or visceral mass of squid and octopus: aquatic animal oil is defined as that oil produced from the baleen whale, sperm whale, dolphin and other aquatic animals. Oil is also produced

Table 13-2. Production of whale oil (tons)

	Antarctic Ocean		North Pacific Ocean		Large type whaling	
	Baleen oil	Sperm oil	Baleen oil	Sperm oil	Baleen oil	Sperm oil
1964	95,376	20,416	11,685	19,456	1,658	6,084
1965	84,208	11,246	14,545	19,524	—	—
1966	40,451	2,585	13,529	22,071	—	—
1967	—	—	—	—	—	—
1968	29,138	750	15,835	20,500	—	—

Table 13-3. Production of liver oil

	Whale and Crude fish liver oil				
	Whale	Cod and Alaska pollack	Shark	Squid	Others
1964	207	8,548	1,142	508	2,143
1965	120	9,222	1,071	1,850	1,396
1966	67	10,315	948	1,477	937
1967	—	14,319	1,131	1,794	1,068
1968	18	11,274	729	1,076	2,537

Table 13-4. Chemical composition of raw fish used as source of fish oil

	Moisture-content	Crude protein	Crude fat	Ash
Herring	74.58%	15.85%	7.82%	1.75%
Sardine	63.08	16.17	17.46	4.00
Atka mackerel	74.41	18.50	3.81	1.27
Saury	63.31	18.83	13.69	3.18
Visceral mass of octopus	74.4	16.4	7.6	1.6
Baleen whale	70.18	20.95	7.62	1.25
Sperm whale	34.8	54.7	10.5	—

from the waste materials from canning or fish sausage or Japanese style fish paste operations.

The general chemical composition of the raw materials from which oils are produced are shown in Table 13-4.

The chemical composition varies according to the species of fish of animal, and also according to the fishing season or place.

III. Separation of Fish Oil

For the separation of fish oil, "steam-cooking" or "boiling water cooking" are first carried out. Steam-cooking is a method to separate oil from fatty tissue of raw materials by steam under pressure. The fat and oil in whale are separated by this method. On whaling mother ships, Hartman type boiler or Kvahner type boiler, which are efficient to boil large amounts at one time, are installed. Steam under pressure is injected into these boilers and the raw material is cooked with continuous stirring. Whale blubber is boiled to liquefy by steaming, and the liquefied oil is completely separated by a centrifuge system.

Boiling water cooking is a method to separate oil from oily fish bodies. The raw material is placed into boiling water in an iron pan and boiled. The oil separated from the fish floats to the surface and is removed from the pan. After boiling the fish are pressed to separate the remaining oil. The press employed for this purpose may be one of many types, e.g., hand press or hydraulic press. Two kinds of hand presses are described in Chapter XI under fish cake making. The cooking and pressing are the same procedures as for making fish cake. Recently a continuous screw press has been employed. The production of fish oil has been carried on in conjunction with manufacture of fish cake or fish meal in Japan. For the separation of oil from whale blubber, open-cooking is still in use at some land factories in whaling shore station as it is one of the best though oldest methods.

The blubber or shark liver is minced and dropped by gravity or raised by conveyor into a large tank where it is cooked with open steam over several feet of water for about 4 to 6 hours at about 180°C. The oil is then cooled somewhat and the sediment allowed to settle before the oil is pumped through a pipe to sepearating tanks. The residue from which the oil is separated is called "cooked skin of whale" which is eaten preferably as a delicacy in the Osaka district.

IV. General Characteristics of Japanese Fish Oil

Fish oils are liquid fats and consist chiefly of glycerides of saturated or unsaturated fatty acids in various proportions. Japanese fish oils are mainly produced from the above described species of fish.

The general characteristics of the principal Japanaese fish oils are as follows.

1. **Sardine oil**

The constants of Japanese sardine oil⑴ produced from sardine caught at known places are shown in Table 13-5.

Table 13-5. Constants of Japanese sardine oil

	Sample I (Aichi Prefecture)	II (Chiba Pref.)	III (Hokkaido Pref.)
Specific gravity $d^{15.5}_{15.5}$	0.9347	0.9318	0.9316
Acid value	1.3	8.2	5.2
Saponification value	195.8	196.2	194.8
Iodine value (Wjis)	180.7	180.59	187.25
Refractive index (20°)	1.4808	1.4802	1.4807
Butyro refractive index	84.3	83.2	84.1
m.p. of mixed fatty acids	35.4°	36.2°	35.8°
Polybromide (fatty acid) (solvent : acetic acid)	47.09%	44.24%	44.88%
Amount of bromide (average of two samples)	69.99%	70.07%	69.98%

2. **Herring oil**

According to Tsujimoto⑵, the constants of herring oil are shown as Table 13-6.

The characteristics of herring oil differ according to the age and size of fish. Therefore it is difficult to identify the herring oil from other fish oil by the constants.

3. Saury oil

Saury (*Cololabis saira*) is caught in too large quantities to process for food, so it is used to produce fish meal and oil. The constants of this oil are shown in Table 13-7(3).

Table 13-6. Constants of Japanese herring oil

	Large herring oil			Small herring oil
	I	II	III	
Specific gravity d^{15}_{15}	0.9182	0.9147	0.9255	0.9234
Acid value	10.4	6.8	2.0	8.4
Saponification value	185.9	185.0	190.5	189.3
Iodine value (Wjis)	103.09	104.45	123.44	143.55
Refractive index (20°)	1.4720	1.4725	1.4747	1.4754
Butyro refractive index (20°)	69.5	70.3	73.8	75.0
Unsaponifiable matter	1.81%	—	0.87%	—
Oxidized acid	—	—	—	0.08%
m.p. of mixed fatty acids	30°	—	31.5°	28.8°
Polybromide (fatty acid) (solvent : acetic acid)	12.68%	—	21.70%	26.11 %
Amount of bromide	69.3%	—	69.93%	69.35 %

Table 13-7. Constants of saury oil

Specific gravity d^{15}_{15}	0.9322
Acid value	14.5
Saponification value	184.7
Iodine value (Wjis)	139.81
Refractive index (20°)	1.4760
Butyro refractive index (20°)	76.0
Oxidized acid	0.26%
Polybromide (fatty acid) (solvent : acetic acid)	26.96%
Amount of bromide	70.04%

4. "Abura-karei" oil

Abura-karei" (oily plaice) (*Cynopsetta dubia*) which is caught in northeastern Hokkaido (Nemuro and Kushiro) is used for production of oil. The yield of oil is about 20 %. The constants of this oil are shown in Table 13-8(4).

Table 13-8. Constants of "abura-karei" oil

	A	B
Specific gravity $d\frac{1}{4}$	0.9181	0.9172
Acid value	6.1	3.8
Saponification value	182.9	187.1
Iodine value (Wjis)	95.88	94.95
Refractive index (20°)	1.4725	1.4730
m.p. fatty acid	—	19~21°C
Polybromide (solv. ether)	—	10.91 %

This oil having a low iodine value and low concentration of unsaturated fatty acid is suitable for use as a raw material for hydrogenated oil.

5. Plaice oil

There are many species of plaice (*Pleuronectidae*), from which 12 *l* of oil is obtained from 150 kg of plaice. The oil is reddish yellow. When it is left in a cold place, stearic acid will crystallize out. This oil is also suitable as raw material for hydrogenated oil. The constants of plaice oil are shown in Table 13-9(5).

6. Mackerel oil

The constants of mackerel (*Scomber japonicus*) oil are shown in Table 13-10(6).

7. Atka mackerel oil

The specific values of Atka mackerel oil (refined oil with kanbara earth) are shown in Table 13-11(7).

8. Squid oil

Table 13-9. Constants of plaice oil

	Plaice in Hokkaido (Nemuro)	Plaice in Hokkaido (Kushiro)	Plaice in Sanriku district	Commercial merchandise
Specific gravity d^{15}_{4}	0.9162	0.9136	0.9240	$0.8650d^{100}_{4}$
Acid value	1.2	12.6	0.8	2.0
Saponification value	183.8	180.4	185.3	184.5
Iodine value (Wjis)	95.9	92.4	118.5	108.3
Refractive index n_D^{20}	1.4710	1.4710	1.4849	1.4591
m. p. mixed fatty acid	——	——	29°	
Polybromide of mixed fatty acid	——	——	18.66 %	
Oxidized acid	——	——	0.72	(solid fatty acid 28 %)
Color	light yellow	yellowish orange	reddish yellow	
Investigators	M. Tsujimoto	ditto	ditto	Ueno and Okamura

Table 13-10. Constants of mackerel oil (Tsujimoto)

Specific gravity (15°)	Acid value	Saponification value	Iodine value
0.9301	1.7	191.6	167.43

Refractive index (20°)	Polybromide (fatty acid)(solv. acetic acid)	Amount of bromide	Butyro refractive index (20°)
1.4811	36.18 %	69.38	84.7

Table 13-11. Constants of Atka mackerel oil (Ueno and Iwai)

Specific gravity d^{15}_{4}	Acid value	Saponification value	Iodine value
0.9153	19.0	183.3	92.11

Refractive index n_D^{20}	Oxidized acid	Unsaponifiable matter
1.4714	0.1 %	about 2.5 %

Squid oil is produced from squid (*Ommastrephes sloani pacificus*) liver in which oil is contained to the amount of 2~3 % of the amount of total body. The constants of squid oil are shown in Table 13-12(8).

Table 13-12. Constants of squid oil (Tsujimoto)

Specific gravity d^{15}_{15}	Acid value	Saponification value	Iodine value	Refractive index$_D^{20}$	Butyro refrative index (20°C)
0.9316	3.9	189.6	177.02	1.4806	84.0

Unsaponifiable matter	m.p. of mixed fatty acid	Polybromide (fatty acid)	Stearic acid	Oxidized acid	Hydrogen value
1.14 %	35～36° C	57.45 %	0.14 %	0.69 %	1.39

9. **Octopus oil**

Octopus liver contains oil to about 2 % oil of weight of entire body. The specific values are shown in Table 13-13(9).

Table 13-13. Specific numbers of Octopus oil (Tsujimoto)

Specific gravity d^{15}_{4}	Acid value	Saponification value	Iodine value	Refractive index$_D^{20}$
0.9305	0.54	173.0	175.0	1.4835

Butyro refractive index	Unsaponifiable matter	m. p. of fatty oil	Polybromide	Amount of bromine
89.1	8.36 %	27～28° C	57.67	70.82

10. **Japanese whale oil**

The constants of whale oil produced by Japanese whaling companies, by species, are shown in Table 13-14(10).

V. Uses of Fish and Whale Oil in Japan

Crude fish oils have unpleasant odor, therefore they have been estimated as inferior quality oil. However, if they are purified, the unpleasant odor can be removed. Fish oils have been utilized as the following items of merchandise.

Table 13-14. Specific numbers of whale oil

Species and part of body		Specific gravity	Acid value	Saponification value	Iodine value	Refractive index (20°)	Butyro refractive index (20°)	Investigator
Fin back	skin oil	0.9221	0.38	193.9	109.7	1.4726	70.5	Tsujimoto
	tongue oil	0.9222	0.52	193.3	110.7	1.4730	71.1	〃
	visceral oil	0.9253	0.51	191.5	134.3	1.4761	76.2	〃
	bone oil	0.9219	0.55	195.1	107.5	1.4724	70.1	〃
White fin back whale	skin oil	0.9208	0.61	192.8	107.6	1.4762	70.5	〃
	tongue oil	0.9216	0.49	191.7	108.9	1.4726	70.5	〃
	visceral oil	0.9203	0.84	191.4	103.4	1.4724	70.1	〃
	bone oil	0.9254	0.44	193.5	110.1	1.4727	70.8	〃
	skin oil	0.9201	0.32	186.4	112.2	1.4733	71.5	Ueno
Hum-back whale	tongue oil	0.9175	0.18	187.2	92.2	1.4737	67.4	Tsujimoto
	visceral oil	0.9201	0.65	191.7	113.5	1.4714	72.2	〃
	bone oil	0.9176	0.46	187.7	98.9	1.4787	68.6	〃
California gray whale	skin oil	0.9288	0.44	188.8	153.7	1.4787	80.2	〃
	visceral oil	0.9292	0.63	190.2	156.4	1.4794	81.8	〃
	bone oil	0.9276	0.74	189.2	152.2	1.4781	79.5	〃
	skin oil	0.9258	0.97	192.6	146.5	1.4762	76.3	Ueno
Sperm whale	skin oil	0.8660		154	74	1.4566		
	junk oil	0.8615		150	77	1.4553		
	red meat oil	0.8780		165	95	1.4602		
	white meat oil	0.8672		147	91	1.4587		
Sei whale oil		0.9886		199	39	1.4587		
Dolphin	head oil	0.9249		279	23	1.4525		
	body oil	0.9286		217	125	1.4717		
	brain oil	0.9260		251	82	1.4653		
	jaw oil	0.9317		261	72	1.4610		
Propoise	jaw oil	0.9258		269	21			
	body oil	0.9260		256	88	1.4625		
Pilot whale	head oil	0.8244		258	50	1.4575		
	brain oil	0.9162		264	18	1.4498		
	abdomen oil	0.9209		204	94	1.4697		

1. Edible fat and oil

Fish oils and mysticeti whale oil consist of glycerides, therefore they can be utilized as edible fat and oil. But since they contain a pretty large amount of unsaturated fatty acids, they must be purified and processed. One of the processes is hydrogenation, where by the oils are hydrogenated until the unsaturated fatty acids will disappear, while the iodine value becomes 50~70, and the melting point becomes 35~38°C. This is perhaps half-hydrogenation. For the hydrogenation, fish oils having high iodine value such as sardine oil or saury oil are not suitable. "Abura-karei" (oily plaice) oil or baleen whale oil is suitable. After the oils are hydrogenated to a predetermined iodine value, the hydrogenated oil is brown with live steam under reduced pressure to remove hydrogenated oil odor. This processed hydrogenated oil is used as raw material for margarine.

2. High hydrogenated oil

Fish oil or whale oil are hydrogenated until all the unsaturated fatty acids become saturated compounds. These hydrogenated oils are used as raw material for cosmetics, stearic acid, glycerine, soap or candles.

3. Painting materials

Fish oils having high iodine value possess a large amount of linoleic acid which is necessary for drying of oil, but they also contain high unsaturated fatty acids and saturated fatty acids. Therefore the dried surface formed from the fish oil paints are weak for water-proofing.
But recently they are prepared as boiled oil after cooling and polymerization have been carried out. Squid oil or sardine oil is used as raw material for paint oils, but they are inferior to vegetable oils such as linseed oil.

4. Factices

Factices are vulcanized oils; They are generally prepared from vegetable oil, but they are also from fish oil. Factices are used as weighting agent of natural rubber, coating agent by heating at 160~190°C after addition of adequate amounts of sulfur. In order to prepare white factice, fish oils are at first oxidative polymerized and reacted with sulfur chloride (S_2Cl_2).

5. Methyl-esters of fish oils

Methyl- or ethyl-esters produced from fish oil are used as cutting oil.

6. Washing agents

Toothed whale oil, such as sperm whale oil, of which the main component is wax, is distilled under reduced pressure after the addition of sodium hydroxide to make higher monohydric alcohol. This alcohol is reacted with sulfuric acid and then is neutralized with alkaline. This is useful for special washing agents. The distillating residue is used for laundry soap.

7. Others

Toothed whale oil is molecular distilled and then the distillate is separated into wax and glycerine, which are separately utilized. Higher alcohol prepared from the toothed whale oil is used for raw material of cosmeticts after refining.

VI. Processed Products from Fish Oil or Whale Oil

Estimated amounts of processed products from fish oil or whale oil from January to February in 1962 in Japan are shown in Table 13-15. (According to statistics of the Japanese Ministry of Trade and Industry)

Table 13-15. Amounts of products from fish oil or whale oil in Japan (January to February, 1962)

Products		Amounts (tons)
Fatty acids	Directly decomposed	6,631
	Decomposition after hydrogenation	2,928
	Total	9,559
	Stearic acid	1,026
	Oleic acid	1,029
	Others	527
	Total	2,381

Hydrogenated oil	As food	9,984
	For industrial use	5,220
	Total	15,204
Soap	For bath	10,896
	For laundry	18,587
	For textile industry	1,147
	For industry	402
	Powdered soap	10,405
	Others	768
	Total	42,205
Crude glycerine		2,424
Refined glycerine		2,774
Higher alcohol washing agent		3,985
Washing agent for mineral oil		23,500

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FISH LIVER OIL INDUSTRY

I. Introduction

Fish livers containing a large amount of vitamins A and D are used to prepare fish liver oils. Prior to as well as after World War II fish liver oils prepared from various species of fish, especially cod, Alaska pollack, shark, have been exported to the United States. The price of vitamin oil depends on the amount and concentration of vitamin A. Therefore vitamin oils are prepared from not only fish liver, but also from viscera, e. g., pyloric appendage or intestine containing vitamin A. For example, most of the Alaska pollack oil has been prepared from not only the liver, but also from other viscera. Such liver oil having high potency of vitamin A is sometimes called vitamin oil.

Recently vitamin oils have been molecularly distilled to concentrate vitamin A, and have been exported. This product is called the "concentrated vitamin oil". The residue of the distillation is used as fish oil. The molecular distillation is carried out by eight or nine vitamin manufacturing companies. The total capacity of molecular distillation of vitamin oil of those companies is about 30 tons per day. After the war bonito liver oil having high potency of vitamin D was exported. However, the amount of the exported bonito liver oil has decreased owing to the production of vitamins D_2 and D_3 synthesized chemically from ergosterol or cholesterol respectively. Recently vitamin A has also been chemically synthesized, but it is still expensive. Thus fish liver oil having a high potency of vitamin A continues to have an export market. In contrast to the chemically synthesized vitamin A, high concentrated vitamin oil made by molecular distillation is practically decomposed to extract unsaponifiable matter, from which other substances, such as sterol, higher alcohols and carbohydrates are removed. The resulting highly purified vitamin A is exported.

II. Production of Fish Liver Oil

The production of fish liver oil (crude) from 1964 to 1968 is shown in Table 14-1.

Table 14-1. Production of fish liver oil (crude) 1964～1968 in Japan (tons)

	1964	1965	1966	1967	1968
Cod and Alaska pollack liver oil	8,548	9,222	10,315	14,319	13,048
Squid liver oil	508	1,850	1,477	1,794	1,076
Shark liver oil	1,142	1,071	948	1,131	729
Others	2,143	1,396	937	1,068	2,537
Total	11,341	13,539	13,677	18,312	17,390
Whale liver oil	207	120	67	–	18

From the total amount of production above described, about 392 tons of fish liver oil including cod, Alaska pollack, rock fish ("menuke"), shark, halibut, tuna and other fish liver oil, were exported to the United States, Canada, U.K., France, Holland, U.S.S.R., Spain, Hong Kong, and Germany. On the other hand, because of the increased domestic demand for fish liver oil, considerable qualities have been imported from various countries.

As interim figures, the amount of fish liver oil imported from foreign countries (Korea, Hong Kong, Formosa, United States, Norway, and Spain is shown in Table 14-2.

Table 14-2. Imported fish liver oil 1964～1967 (kg) (Ministry of Finance)

1964	1965	1966	1967
349,576	580,768	277,901	382,504

The imported amount of synthesized vitamin A is also shown in Table 14-3.

Table 14-3. Imports of synthetic vitamin A (kg)

1964	1965	1966	1967
18,985	33,803	52,606	74,029

The vitamin A (chemically synthesized) is imported from the United States, Holland, Switzerland, West Germany, and U.K.

III. Raw Marterial

There are many species of fish, of which the liver or viscera are used as raw material for vitamin oil. The potencies of vitamins A and D vary according to the species. Therefore it is important to find the species of fish having high potencies of viscera, the amounts of vitamins A or D may be estimated. The units of vitamin A in liver or viscera of many species of fish in Japan which are used industrially are shown in Table 14-4⁽¹⁾. The vitamin D varies markedly according to species of fish. Vitamin D in the liver oil of bonito or tuna is high as compared with that in shark liver oil. The units of vitamin D in the liver or viscera of several fishes in Japan which are used industrially are shown

Table 14-4. Units of vitamin A in liver or viscera of different species of fish (Higashi)

Kinds of fish	Units of vitamin A (I.U.)
Cod (*Gaddus macrocephalus*)	1,000 - 12,000
Alaska pollack (*Theragra chalcogramma*)	3,000 - 30,000
Oily shark (*Heptranchias perlo*)	1,000 - 80,000
Hammerhead shark ("shumoku same") (*Sphyrna zygaena*)	20,000 - 150,000
Other shark	1,000 - 50,000
Big tuna (Bluefin tuna) (*Thunnus orientalis*)	100,000 - 150,000
Small tuna (〃)	15,000 - 30,000
"Meji maguro" (young tuna) (〃)	30,000
Big eyed tuna (*Parathunnus sibe*)	20,000 - 60,000
Striped marlin ("Makajiki") (*Tetraoturus mitsukuri*)	30,000 - 70,000
Broad bill swordfish ("Makajiki") (*Xiphias gladius*)	40,000 - 100,000
Rock fish ("Menuke") (*Sebastodes sp.*)	50,000 - 100,000
Mackerel (*Scomber japonicus*)	5,000 - 100,000
Oily plaice (*Reinhardtius matsuurae*)	50,000 - 200,000
Yellowfin tuna (*Neothunnus macropterus*)	30,000 - 60,000
Jew fish ("Ishinagi") (*Stereolepis ischinagi*)	200,000 - 700,000
Bonito (*Katsuonus vagans*)	10,000 - 300,000

in Table 14-5(1).

Table 14-5. Units of vitamin D in liver viscera of several fish (Higashi)

	Units of vitamin D (I.U.)
Cod	20 - 30
Marlin	2,000 - 25,000
Rock fish	300 - 5,000
Halibut	550 - 20,000
Bonito	25,000 - 250,000
Oily shark	0 - 60

IV. Processing of Fish Liver Oil

In Japan processing of fish liver oil is carried out by alkali-digestion, enzyme-digestion, or solvent extraction.

If fish liver oils are obtained from livers by means of a steam cooker, a large quantity of vitamin A will remain in the screenings (residue) left after pressing. In the steam-cooking, the liver oil will float to the top. This is called floating oil. Vitamin A left in the screenings (residue) can be solvent-extracted. This is the extracted oil. The order of concentration of vitamin A in each oil prepared by various methods is found to be as follows:

Extracted oil>Screened oil>Floating oil

The concentration of vitamin A in the extracted oil ranges from a half to many times that obtained in the floating oil or in screened oil. The amount of oil left in the screening is 10~30% of the total amount of oil in the raw livers, but the amount of vitamin A in the former is 30~90% of that in the latter. Therefore the processing of vitamin oil by boil-cooking method is unsuitable.

Solvent extraction methods are not employed for the preparation of vitamin A oils from fish livers, because the equipment is expensive and the recovery of the solvent is not satisfactory. At present, vitamin oil is treated out by the alkali-digestion method or the enzyme-digestion method. The yield of vitamin A secured by alkali-digestion is 70~95% of that in raw livers.

1. Alkali-digestion method

The livers are first ground in a meat chopper. The chopped livers are digested at 40°~50°C by autolytic enzyme after the addition of water, until the solids of the liver are liquefied. To the digested liver a calculated minimum amount of sodium hydroxide solution is added in the amount of 1~2% for shark livers, or 4~6% for whale liver, and the digestion is continued at 40°~80°C. The pH value of the alkali-digested liquor should be adjusted to approximately 9 with HCl or NaOH solution. The digested liquor is then passed through a centrifuge. If livers of low oil concentration and high vitamin A potency, such as tuna liver, marlin liver, whale liver are extracted, "picking-up oil" such as Alaska pollack liver oil or shark liver oil having low vitamin A is added to the digested liquor in order to increase the potency of vitamin A, before the centrifugation. The centrifuged oil probably contains suspended soap or excess alkali, so further centrifugation is necessary after washing with warm water. The defect of this alkali-digestion is the loss of vitamin A and the decomposing and dissolving of water-soluble vitamins which are contained in fish livers besides vitamin A, during this sort of treatment.

2. Enzyme-digestion method

This method employs other viscera (pyloric appendage and alimentary canal) to complete the digestion of the liver cells for the release of the oil. The livers and other viscera are minced or disintegrated and the solids of the liver are digested to liquefy with enzyme of the liver and viscera, sometimes with the asistance of a commercial proteolytic agent (e.g., "Bioprase", Nagase Industrial Co.. Osaka, from *Bac. subtilis*).

The digested liquor is first passed through a continuous solid separator and then passed through a centrifuge, which separates the vitamin oil in the form of an emulsion. The emulsion is passed through a sharples type centrifuge to separate the oil as completely as possible. In the case of low oil concentration and high vitamin A potencies, "picking-up oil" is added to the digested liquor before the centrifugation, In this method, the separated water is used to prepare "fish solubles" for livestock feed. At present, this method is widely used in Japan.

V. Molecular Distillation of Vitamin Oil in Japan

It was in 1948 that vitamin oils were first molecularly distilled in Japan. Afterwards the molecular distilling apparatus became common place. The apparatus popular in Japan is the improved apparatus of the falling film type, which was designed by the Nippon Rika Kogyo Co. The yield of vitamin A distilled out is 92～95% of the total amount of vitamin A in the raw livers. The concentration of vitamin A in the vitamin oil thus distilled out becomes 1.5～5 times that in original vitamin oil (liver oil). The vitamin oils distilled out by molecular distillation contain a large amount of glycerides and have an unplesant odor. It is reported that this odor can be largely removed by passing hydrogen gas through the oil.

However, a trace of the odor remains. Since 1924, studies on the concentration of vitamin oil by the decomposition method have been made by Dr. Takahashi (Institute of Physics and Chemistry, Tokyo); and a product under the commercial name "Biosterin" is sold, which contains 60～70% of vitamin A. Since 1950, studies on the extraction of unsaponifiable matter, from which impurities besides vitamin A are removed, have been carried out. An industrial method has been developed, by which a yield of 95～98% of vitamin oil containing 70～90% of vitamin A, is obtained. By this industrial method a large amount of vitamin oil has been produced in Japan. From an ester of vitamin A, pure vitamin A has been produced as crystals. The concentrated vitamin oil prepared by the industrial method contains vitamin D besides vitamin A. Therefore, vitamin D is obtained from impurities separated from unsaponifiable matter from which sterol was removed.

VI. Uses of Vitamin Oil in Japan

Vitamin oil containing vitamins A and D is used for medicines, or for the enrichment of foods and fodder. The amounts of production, export, and domestic consumption vitamin oil in Japan are shown as Table 14-6.

Table 14-6. Production, export, and domestic use of vitamin oil in Japan in 1967 (kg)

Amount of production		111
Exported to	U. S. A.	76
	Europe	22
	Others	37
Domestic use	Medicine	11.7
	Enrichment for foods	3.7
	Fodder	8.3
Imported amount		13.7

The demand of vitamin A for domestic use has been increasing year by year. The concentrated vitamin oil containing vitamins A and D is less expensive than the synthetic vitamin A. There is no anxiety for the increasing amount of domestic consumption because the production of vitamin oil is increasing.

VII. Standards and Inspection for Exported Crude Liver Oils

According to law crude liver oil shall be graded into Grade A and B subjecting to the following standards.

1. Standards

Table 14-7. Standards and inspection for crude liver oils
(a) Low potency oil

Criteria	Grade A	Grade B
Vitamin A potency	Vitamin A potency shall not be less than 850 units per gram and not more than 40,000 units per gram ; the units shall be determined accurately under the method described in separate paragraph.	Same as for Grade A
Free fatty acid	Free fatty acid shall not be more than 2 per cent of water under the method described in separate paragraph.	Below Grade A

Water and sediment	Oil contains not more than 1 per cent of water and sediment under the method described in separate paragraph.	Same as for Grade A

2. Assay for free fatty acids

Dissolve about 2 g. of oil accurately weighed in 30 ml of a mixture of equal volumes of alcohol and ether (which has been neutralized to phenolphthalein with 0.1 N sodium hydroxide), contained in flask. If the sample does not dissolve in the cold solvent, connect the flask with a reflux condenser and warm slowly with frequent shaking until the sample has dissolved. Add 1 ml of phenolphthalein (T.S.) and titrate with 0.1 N sodium hydroxide until the solution remains faintly pink after shaking for 30 seconds. Free fatty acids of oil are then obtained by the following formula:

The percentage of free fatty acids

(b) High potency oil

Criteria	Grade A	Grade B
Vitamin A potency	Vitamin A potency shall be more than 40,000 units per gram and the units shall be determined accurately under the method described in a separate paragraph.	Same as for Grade A
Free fatty acids	The free fatty acids shall be more than 1 per cent under the method described in a separate paragraph.	Below Grade A
Water and sediment	Oil contains no water and sediment under the method described in a separate paragraph.	Oil contains not more than 0.5 per cent of water and sediment under the method described in a separate paragraph.
Stearin	Oil turns clear at 45°C.	Below Grade A

$$= 0.0232 \times \left(\frac{\text{The volume of 0.1 N sodium hydroxide required to neutralize the sample solution}}{\text{The amount of sample expressed in grams}} \right)$$

3. Assay for moisture and sediment

Place exactly 50 ml of benzene in each of two centrifuge tubes and to each tube add exactly 50 ml of the oil, warmed. If necessary, to reincorporate separated stearin, and throughly mix at 25°C. Tightly stopper the tubes and shake them vigorously until the contents are throughly mixed, then immerse the tubes in a waterbath at 50°C for 10 minutes. Place the tubes on sides of the centrifuge and whirl for 10 minutes. Read the combined volume of water and sediment at the bottom of each tube. Repeat the whirling for 10 minutes periods until the combined volume of water and sediment remains constant for three consecutive readings. The sum of the volumes of combined water and sediment in the two tubes represents the percentage, by volume, of water and sediment in the oil.

Note: The preferred centrifuge should have a diameter swing (tip to tip of whirling tubes) of from 38 to 43 cm, and be operated at a speed of about 1500 r.p.m. The centrifuge tubes should be graduated according to the following scale:

Range (cc.)	Scale Division (cc.)
0 to 3	0.1
3 to 5	0.5
5 to 10	1.0
10 to 25	5.0
25 to 50	25.0
50 to 100	50.0

4. Export standard for container

(a) Container of 180 kgs. net weight.

To be filled in drum specified by Japanese Industrial Standard Z 1601-1 or in those having equal or more capacity, with little damage, even surface, little corrosion by rust. Container shall have a tight lid and U.S.P. units of vitamin A or its code shall be labeled on the side.

) Container or less than 180 kg. net weight.

To be filled into an undamaged container with an even surface and little corrosion by rust. Container shall have tightly fitting lid and U.S.P. units of vitamin A or its code shall be labeled on the side.

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MARINE ANIMAL LEATHER

Leather from whale or shark were produced in Japan on a scale for shoes before World War II. After the war, the production of these leathers came to a stop owing to the increase of imported land animal hides. Recently leather from *Eptatretus bürgerii* ("mekura-unagi") or *Gymnothorax kidako* ("utsubo") has been produced by home-industries for pouches or for Japanese style leather sandals, but the enterprise is not economically important.

I. Whale-hide Leather

The hide of a whale carried very heavy blubber. The hide itself is very thick. The hide is slit into two or three layers. Each layer has been tanned by the same methods as those for land animal hides.

II. Sharkskins

Sharkskins are tanned by the same methods in the United States. However in Japan the shagreen is removed with hydrochloric acid and salt instead of with sulfuric acid as used in the United States. When the salted sharkskins arrive at the tannery, they are placed in pits containing fresh water, which serves to soften the skins and remove the salt. They are then transferred to lime liquor in order to open the fiber bundles and remove the cementing material similarly as done with land animal skins. As in the handling of hides they are fleshed on the machine and then bated to remove the excess of lime and to open up the stock. If the skins are to receive a vegetable tanning, they are placed in a paddle vat containing a solution of tanning extract (from sp.gr. 1.008 to 11.02) . When the skins have absorbed the required amount of tannin, they are taken out from the paddle vat. At this stage of the process the shagreen is treated with conc. HCl solution and NaCl. The tanned sharkskins (100 parts) are put in a paddle vat again in which conc. HCl solution (160 parts) , NaCl (20～50 parts) and water (200 parts) have been put. The paddle vat is rotated for 2～3 hrs at room temperature. When the tanned sharkskins are put in a vat, the soaking time is 4～6 hrs. The sharkskins treated with HCl solution are then well washed to remove the excess of acid. Even if the sharkskins are well washed, some of the acid which penetrated into the skins will be left. The remaining acid is neutralized by soaking in an equal volume of 3～7% sodium hyposulfite. After neutralization, the skins are well washed. Subsequent to washing, the skins are put again into a solution of tanning extract (sp.gr. 1.024) . The skins are finally fat-liquored to prevent hardening and are hung up to dry. Finishing operations are the same as those used in preparation of land animal leather.

III. Small size Fish Skin

The skins from *Eptatretus bürgerii* or *Gymnothorax kidako* have beautiful colored speckes on the surface which remain after tanning. Furthermore, these skins have a high fat content and must be defatted. Defatting is carried out by the following methods twice before and after tanning. Defatting before tanning is accomplished out by pressing the skin after over night salting, or by washing with soap. Sometimes the skins are soaked for defatting in a mixed sloution of sodium sulfate and Japanese acid clay (Kanbara earth). After the tanning, defatting is done by washing with soap solution or gasoline.

The tanning process uses formalin after preliminary treatments of the skins. The formalin tanning solution is made as follows : sodium chloride 50 g., potassium nitrate 20 g, commercial formalin 27 ml are disolved in 12 *l* of water, which is adjusted to pH 7～9 with addition of sodium carbonate solution, and heated to 30° C. The bated fish skins are soaked in the formalin tanning solution for 2 hrs stirring frequently.

After 2 hours, 14 ml of commercial formalin is added to the tannage solution and the solution is adjusted to pH 7~9 again with addition of sodium carbonate and is heated to 40°C. After two hours treatment, to the tanning solution formalin is again added and temperature raised to 45°C. The tanning is finished after a total elapsed time of 6 hours. The tanned skins are neutralized by soaking in 1% alum solution of which the volume is 10 times that of the skins. After the tanned leather is well washed, it is hung up to dry. After the drying the surface of the leather is defatted with gasoline and is glazed with a glazing agent. Those leathers are used for purses, hand-bags or Japanese style sandals.

FISH-GLUE

The fish-glue industry is not economically important. Before World War II, several factories were operating in Japan. But since the war there are few such factories, because this enterprise is unprofitable. The great obstacle confronting the industry is the difficulty of obtaining a regular supply of suitable stock in sufficient quantities. Practically all the fish glue now manufactured is made from the waste products from fish sausage or Japanese style fish processing, e.g., from Alaska pollack, sharks, and others. Among them sharks have thick skin and therefore the yield is rather large.

Methods of Manufacture of Fish-Glue in Japan.

There are several kinds of fish-glue: skin glue, fish-meat glue, and bone glue. In Japan skin glue is produced in small quantities. The glue stock, regardless of whether it is obtaind from fresh or salted fish, is washed and soaked fresh water to remove salt or dirty substances. After the soaking, the skins are cut in small pieces which are transferred to lime liquor in order to open the fiber bundles and remove the cementing material. After washing the limed skin pieces they are bated to remove lime. They are then thoroughly well washed. The washed skin pieces are put into a steamjacketed, doublebottomed cooker. At this stage, a small amount of acetic acid is added to hasten the hydrolysis of the stock into glue and to act as a catalytic agent. The cooking temperature should be 50°～60°C for 6～10 hours for shark skin. Then the glue liquor is drawn off, pumped into tanks and then to an evaporator (open pan type or vacuum evaporator). Evaporation is continued until the glue reaches the proper viscosity. The glue when it has the proper viscosity is drawn off into a coolng box and is cooled below 15°C for 12～18 hours to coagulate. The coagulated jelly type glue is cut in moderate sizes and then dried in a dryer. Fish-glue is used to size cloth or straw hats. In Japan glue prepared from land animal skin is employed for many purposes, while fish-glue has but few uses.

ALGINIC ACID INDUSTRY

I. Introduction

Alginic acid was discovered in 1833 by Stanford⑴. During World War II the alginic acid industry was extended owing to the search for substitutes for agar-agar. According to Japanese Ministry of Commerce, recent figures on production capacity of alginic acid in the world (1956) are shown in Table 17-1.

Table 17-1. Production of brown algae and the producing capacity of alginic acid in the world (1956)

	Amount of production of brown algae (kg)	Producing capacity of alginic acid (kg)
Japan	75,000,000	908,000
U.K.	67,500	908,000
U.S.A.	31,875	2,724,000
Australia	5,625	454,000
New Zealand	1,875	—
South Africa	1,125	227,000
Chili	1,125	227,000
U.S.S.R.	1,125	227,000
Sweden	750	136,200
Norway	750	136,200
Germany	750	90,800
France	750	45,400
Canada	750	45,400

The amount of production of brown algae in Japan is the largest in the world, but the total producing capacity for alginic acid relatively small owing to the low production capacity per one factory and high price of fuel and electricity. In the alginic acid industry in Japan sodium alginate has been produced. This has less coagulating effect than agar-agar, but a stronger viscosity. The number of factories was 30 in 1947, but has decreased to only a few factories at present. This is owing to the low producing capacity and high price of fuel and electricity as described above. However, the increasing use of alginic acid is expected to accelerate its production in future.

II. Processes of Manufacturing Alginic Acid and Alginates

In Japan, Stanford's process or the Kelco process has been improved and the following procedures are carried out. Brown algae are soaked in dilute HCl solution for 4~8 hours to remove colored substance, potassium chloride, iodine and mannitol. After removal from the solution, the kelp is dissolved with 5~10% sodium carbonate or sodium hydroxide at 40°~50°C. Water is added to the dissolved kelp to facilitate filtration. The diluted solution is centrifuged by various centrifuge systems. Then, sodium hypochlorite having 1% available chlorine is added to bleach to the centrifuged transparent solution. When hydrochloric or sulphuric acid is next added to the solution to adjust the pH value to 3, alginic acid will be precipitated. The alginic acid obtained is neutralized with sodium hydroxide to form sodium alginate will be obtained. The alginate is dehydrated by means of methanol and dried. The expense of the production of alginic acid or alginates depends on the kind of algae collected, the collecting season, producing places, efficiency of filtration, and recovery of methanol after the dehydration.

III. Recent Uses of Alginates in Japan

The uses of alginates in Japan in 1956 are shown in Table 17-2.

Table 17-2. Uses of alginates in Japan (1956)

Uses	Amount of use
Textile dyeing	150,000 kg
Textile sizing	100,000
For Food	100,000
Medicine and cosmetics	50,000
Others	50,000
Total	450,000

With the increase in the demand for alginic acid or alginates, the production is expected to increase, if the cost can be lowered.

IV. Mannitol and Iodine-Making

In order to lower the cost of making alginic acid, chemical components, such as mannitol, iodine, and potassium chloride, should be obtained from brown algae. Among those components, mannitol is contained in the largest amount, and it is the most valuable. Research on the economical recovery of mannitol from brown algae has received Japanese Governmental support. Two methods have been developed;

(1) Before the extraction of alginic acid, mannitol is extracted with liquid ammonia or methanol. The extracted mannitol is bleached, condensed to crystal, recrystalized and then at last dried. The liquid ammonia or methanol used will be recovered and re-used.

(2) The waste solution of hydrochloric acid, by which alginic acid was extracted, contains mannitol, iodine and potassium chloride. It is treated with Japanese acid clay (Kanbara earth) to remove the substances besides mannitol and then the solution is filtered. The filtrate is condensed in an oven and the condensed solution is treated with an ion exchange resin. Copper sulfate is added to the solution make the copper salt. This copper salt is filtered and the filtrate is electrolyzed to separate mannitol. The solution is the evaporated to obtain mannitol, which is dried.

Each method has its merits and drawbacks. Therefore they must be studied further for industrial applications. The production of mannitol on a commercial basis will be carried out in future.

Iodine-making is not economically important. From old times, a few iodine-making factories have been located in Hokkaido, in which a simple process based on an early of European method is practiced. The ash of seaweed (kelp) is leached with water, and the solution is evaporated in iron pans over a fire until a mixture crystallizes. These crystals are removed and the solution drawn off and allowed to cool. Relatively pure potassium chloride crystallizes out. This evaporation and cooling processes are repeated until the mother-liquor becomes fairly concentrated in iodides. The remaining liquor is then heated in a porcelain still with manganese oxide and sulfuric acid. The iodine which is driven off is collected and later it is putrified by sublimation. The amount of production of iodine in Japan is small and its production cost is high.

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INSULIN-MANUFACTURING

I. Introduction

Insulin, which has been prepared from pancreas of domestic cattle, is widely used for the treatment of diabates. In higher animals, insulin is secreted from Langerhans' islets, which are scattered in the pancreas. However, in many teleostei fishes these Langerhans' islets are not scattered in the pancreas, but are attached to the gall-bladder, bile duct or mesentery.

When domestic cattle are employed as the source of insulin, a small amount of insulin contained in large volume of pancreas may be separated. On the other hand, when fishes are employed, insulin can easily be separated in high purity from independent Langerhans' islets in which the insulin is present in a concentrated condition. This is a good point. Another good point is that fish insulin is stable even after the death of the fish, because it is present in independent Langerhans' islets which are attached to gall bladder, bile duct or mesentery. On the other hand, insulin from domestic cattle is easily decomposed by trypsin secreted from pancreas.

There are a few factories in which insulin is separated and prepared in Japan. One of them employs viscera of tuna and bonito. The other uses pancreas of whale.

II. Raw Materials

The raw materials (viscera) should contain a large amount of good quality insulin. Among raw materials, tuna and bonito are the most suitable, because they are processed for canning, freezing of fish stick ("katsuo-fushi") in large quantities and large amounts of waste materials (viscera) are available. Another of the raw materials is whale pancreas, which is very large in size (fin whale or sperm whale pancreas weights about 15~30 kg, that of sulphur-bottom whale is 50~100 kg, that of a cow is 0.3 kg).

Langerhans' islets in the viscera of bonito or tuna are stable. For example, the amount of insulin separated from such unfresh bonito that emits a spoiled odor, is a half of that from fresh bonito (24 hrs after the catching). If fresh bonito is rapidly frozen, the yield of insulin will not change even after several months of the storage. On the other hand, Langerhans' islets in cod decompose rapidly. For example, the amount of the islets decreased after 24 hrs to one-third of that present in freshly caught. The amount decreased after 48 hrs to only one-ninth. With the lapse of time, the islets become soft and useless for raw material of insulin.

At present, in Japan, the principal raw materials are derived from bonito (*Katsuonus vagans*) and whales, while auxiliary raw materials are obtained from albacore and yellowfin tuna. Cod pancreas is also sometimes employed.

The yields of insulin(1) from various species of fish are shown in Table 18-1. Langerhans' islets of bonito and tuna have been especially well studied. As seen in Table 18-1, the average weight of the islets in big-eyed tuna is 0.09 g, that in bonito is 0.03 g. The units of insulin-content come to 120 I. E. (International Unit) per 1 g of Langerhans' islets from tuna, while those from bonito are 120 I.E. The yield amount of crude insulin is about 1.5 % of the weight of Langerhans' islets in either tuna or bonito. As to the purity, 1 mg of the crude insulin in bonito or tuna corresponds to 7.7 I.E. Here, 1 I.E. has a potency of 0.45 mg of the international standard pure insulin crystaline available for decreasing the amount of glucose in blood. There are two Langerhans' islets in the viscera of bonito, one of them weighs about 0.1 g, buried half-way near the middle lobe of liver, and the other is half that weight, near the bile duct at the left side of the liver. There are also two islets in tuna, one of them is about 0.15 g; it is buried half way near the tip of the middle lobe of the liver, and the other is one-tenth of the former in weight; it is present at the base of bile duct.

As to whale, insulin is contained in the pancreas. Generally speaking, insulin contained in that organ is easily decomposed. If the freshness of

Table 18-1. Size color and weight of Langerhans' islets in viscera according to various species of fish

Species of fish	Langerhans' islets				Yield of Insulin	
	Location	Shape	Color	Weight(g)	Units per 1 g of Langerhans' islets	Units per one fish body
Albacore	Near the base of gall-bladder	oval	pink	0. 08～0. 18 (ave. 0.12)	193	19. 0
Yellowfin tuna	Neck part of gall-bladder	oval	white	0. 06～0. 33 (0. 18)	173	22. 9
Big eyed tuna	ditto	oval	white	0. 04～0. 13 (0. 09)	136	17. 9
Bonito	Middle lobe of liver, near bile duct	oval	greyish pink	0. 01～0. 08 (0. 03)	109～129	9. 4～11. 6
Cod	Tip of gall-bladder	semi-spherical	pink	0. 01～0. 03 (0. 03)	154	12. 0
Rock fish	Middle of bile duct, near pancreas	oval	white	0. 04～0. 18 (0. 06)	194	13. 0
Yellow tail	Near base of pyloric appendage, near liver and bile duct	oval	white	0. 18～0. 23 (0. 2)	127	16. 4
Salmon	Near neck of gall-bladder	oval	white	0. 04～0. 06 (0. 05)	—	—

the pancreas falls, the unit value of insulin will decline. At the present time the pancreas removed from fin whale or sperm whale is frozen shortly after catching, and is brought to a land factory for immediate extraction of the insulin. The yield of insulin from the whale is less than that from the cow, but the volume of the pancreas in whale is large, so that the enterprise may be profitable. The total amount of I. E. of insulin produced in Japan is about 2 thousand million I.E., which sufficiently meets the demand for the domestic use.

III. Procedures in Manufacturing Insulin

The manufacturing procedures consist of (1) fixing of the chemically useful components of insulin, (2) extraction, and (3) refining.

1. Fixing

The fixing is the most important procedure in manufacturing insulin. Generally speaking, some hours elapse from catching to the extraction of insulin, even if the operation could be done as soon as possible. This is true because the collection of an economically extractable weight of Langerhans' islets requires several hours. During the accumulation, the freshness of the islets will fall, therefore they must be fixed as soon as possible after removing from the viscera mass. Langerhans' islets taken out are soaked in saturated picric acid of 10 times the volume of the islets, and then are stored in a cold place. In another procedure, the islets are crushed with picric acid in mortar, and are transferred into saturated picric acid solution. As to the islets of bonito or tuna, they can be stored in frozen state without damage of effective compounds.

2. Extraction of insulin

There are two methods for extracting insulin: Scott's method (from pancreas of domestic cattle or whale), and Dudley's method (from Langerhans' islets of fishes). The two methods have been employed in Japan.

a. Dudley's method(2)

The principle of this method is that picrate of insulin is dissolved by acetone, but picrates of other proteins are not dissolved. The picrate of insulin separated from picrates of other proteins by acetone is dissolved with HCl-alcohol making water- soluble-insulin hydrochloride. This method is very convenient, but the recovery of acetone used is a key point.

b. Scott's method(3) (HCI-alcohol method)

The crushed pancreas (in the case of whale frozen pancreas) is extracted by acidic alcohol with hydrochloric acid, and the extract is adjusted to pH 8 to precipitate other proteins being mixed with insulin. The precipitate is removed by centrifuging. To the supernatant liquor is added NaCl to make a precipitate of insulin hydrochloride. The insulin hydrochloride separated by centrifuge is dissolved with slight alkaline solution and then it is again precipitated with slight acidic solution. This method to separate insulin from other proteins is difficult, and the yield of insulin is small.

3. Refining

To the water solution of insulin hydrochloride is added alkali, adjusting the pH value to about 5, at which point insulin is the most abundantly precipitated. This treatment is repeated many times. In course of this refining, the loss of insulin is quite large. In order to improve the yield, several methods have been invented, but they are kept secret by the respective factories.

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ORNAMENTAL MATERIALS FROM MARINE PRODUCTS

I. Pearl Industry

1. Introduction

Pearls are divided into two categories: natural or genuine and cultured pearls. Natural or genuine pearls are formed when some foreign substance is accidentally ingested into the shell of a pearl-bearing mollusk. Cultured pearl was originally initiated by removal from a living oyster of the mantle parenchyma which is used as a bag to envelop the nucleus of the pearl. When this nucleus, which consists of a fragment of fresh-water mussel, has been inserted into the bag, its mouth is secured with a thread and the whole is introduced through a surgically made opening into the subcutaneous tissue of the shell-secreting epidermis of another oyster. At the same operation the thread is withdrawn and then returned to the sea and left to cover the nucleus with as many layers of nacre as necessary to produce perfectly spherical pearls. There is no difference between natural and cultured pearl in the microscopic pearl itself or in the structure. However, the natural pearl is higher in price than the cultured pearl owing to its relative scarcity.

The prevalence of natural pearls has been decreasing owing to the deterioration of fishing grounds in the world. Natural pearls have been produced up to the present time in the Persian Gulf, around the northwest Coast of Ceylon, in the Bay of Aden in the Red Sea, on the coast of Northwestern Australia and in the South Seas. On the other hand, as to the cultured pearls, since the success of Kokichi Mikimoto in 1844 there has been considerable advancement in the technique of growing cultured pearls. It was found that it was unnecessary to make a "surgical" operation on the pearl oyster: instead, one or more mother-of-pearl beads may be inserted into the mantle parenchyma to start the process of calcium carbonate deposition around the nucleus or irritant. At present, the enterprise has now become one of mass production in

Japan.

The yield of pearl oysters, and the number of rafts are 79 tons (large pearl 18 tons, medium 33 tons, small 27 tons and 213,182 rafts) in 1962.

2. Kinds of pearl oyster

There are several types of pearl oysters in Japan.

a. Sea water pearl oysters

(i) "Pearl oyster" (*Pinctada martensii*) ("Akoya-gai")

This is the principal cultured pearl oyster of Japan, and it supplies 99.8% of the total amount of the production.

(ii) "Shiro-cho-gai" (*Pinctada maxima*)

The pearl deposited in "shiro-cho-gai" is almostly semispherical in shape. This is cultured in the Melgie Islands in Burma.

(iii) "Kuro-cho-gai" (*Pinctada margartifera*)

The pearl is this shell is greyish silver and semi-spherical in shape.

(iv) "Mabe" (*Pteria macrontera*)

The pearl in this shell is iridescent silver white and semi-spherical shape.

b. Fresh water pearl oysters

Such pearl oysters are cultured in lakes.

i) "Ikecho-gai" (*Hyriopsis schelegelli*)

The pearl in this shell is brownish pink. This mussel is cultured in Lake Biwa. The production is not yet abundant (about 100 kg of pearl per year).

ii) "Karasu-gai" (*Oristariria spatiosa*)

The pearl in this shell is similar as that of "Ikecho-gai". This mussel is cultured experimentally in Nagano, Gifu, Chiba and Ibaragi Prefectures.

3. Classification of cultured pearls for commerce

a. By shape and use

The cultured pearl is classified by shape and use into several categories.

- Pearl
  - Pearls in bulk (L.p.)
    - Half sphere (1/2)
    - Whole sphere
    - Three quarter (3/4)
  - Pearls threaded with string (S.t.)
    - Necklace
    - Choker
    - Rope
    - Bracelet

The percent of exports of each kind of pearl is shown in Table 19-1.

Table 19-1. Percent of exports of each kind of pearls

	1959	1960	1961
Pearls threaded with string	68.9	72.7	73.5
Pearls in bulk	17.8	15.8	14.8
Half sphere or three quarter sphere	13 3	7.8	1.2

b. By weight and size

The pearls in bulk offered on the market are classified into 6 categories by size.

Table 19-2. Classification of pearls in bulk

Kind	Diameter
Super small pearl	less than 3 mm
Extra small	3 ～ 4.5 mm
Small pearl	4.5 ～ 6.0 mm
Middle pearl	6.0 ～ 7.5 mm
Large 〃	7.5 ～ 9.0 mm
Extra large pearl	larger than 9.0 mm

The sizes of pearls for necklace are shown in Table 19-3.

Table 19-3. Sizes of pearls for neck

	Weight (g)	Graduated size necklace			Uniform sized necklace	
		Length (inch)	Center pearl	End pearl	Length (inch)	Each size
Small pearls necklace	less than 11.2	17	less than 6 mm	less than 3 mm	14	less than 4.5 mm
popular pearls necklace	11.2～18.7	17	larger than 6 mm	larger than 3 mm	14	larger than 4.6 mm

Middle pearls necklace	18.7～26.2	17	larger than 8 mm	larger than 3 mm	14	larger than 6 mm
Larger pearls necklace	26.2～35.6	18	larger than 8.5 mm	larger than 5 mm	14	larger than 7 mm
Extra large pearls necklace	larger than 35.6	18	larger than 10.0 mm	larger than 6 mm	14	larger than 8.5 mm

c. Classification by color

Pearls are also classified by color: white, pink, gold, green, blue and black. Many pearls show mixed colors.

4. Governmental regulation for inspection of exported pearls

In order to assure export of good quality pearls, those produced in Japan are inspected at the Governmental Pearl Inspection Station. They are inspected for shape, color, brightness, size of pearls, mother of pearl, the presence of defects, workmanship, harmony of necklace, etc. These factors are evaluated by scientific and naked eye inspections. Nonexportable pearls are discarded on block in the deep sea every year.

II. Ornamental Shell Products

The various kinds of pearl oyster shells have been utilized for various ornamental products in Japan. The carving technique was developed 1,200 years ago. The shell objects made in that age are to be seen in the Museum "Shoso-in" in Nara. In the age of the Tokugawa Shoguns (about 170 years ago), the carving technique developed.

The principal items produced are core from shells, buttons, inlaid objects and carved shells. The species of shells of mollusca used for the purpose of making those objects are as follows. The core used for the cultured pearl is made from *Pinctada maxima* ("shiro-cho-gai"); buttons are made from thick shells exhibiting hardness and mother-of-pearls, such as "takase-gai" (*Trochus sacellum rata*): inlaid objects use shells having beautiful mother-of-pearl, such as abalone, or "shinju-gai", and carved shells are made from shells having an interesting shape, such as top-shell.

1. Core-making industry

A core is put into the mantle parenchyma of oysters to produce blister or baroque pearls. Cores made from pig-tow shell in the Mississippi River are imported from the United States or they are made from "shiro-cho-gai" (*Pinctada maxima*). At present the core-makers number 80 in Osaka and near by areas (Nara, Mie and Hyogo Prefectures). The procedure for making cores consist of cutting the large shell to small pieces by a press, round-shaping, sphere-making, and polishing. The yield of such cores is 2.5~3 % of the weight of raw material of shells.

2. Buttons

The first hand production of buttons from pearl shells in Japan occurred about 70 years ago. Almost all of the production has been exported to foreign countries at present amounts to approximately 3.3 million dollars annually. The principal raw shells is from "takase-gai" (*Trochus sacellum rata*). From "shiro-cho-gai" (*Pinctada maxima*) large-sized buttons, and from abalone and top-shell (*Turbo cornuts*) thin small-sized buttons are manufactured. The areas of production are Osaka, Hyogo, Nara and Wakayama Prefectures. The procedures of manufacturing buttons are similar to those in the United States.

3. Inlaid objects

The mother-of-pearl of various species of shells is freed from the shells and is inlaid in the surface of thin wooden boards for making boxes, or the hafts of knives.

4. Carved shells

Ornaments are carved from shells. Such articles are made as special products at sea shore cities or towns. For example, there are cigarette ash trays, ink bottles or flower vases.

III. Tortoise Shell Products

In Japan, Hawksbill tortoise shell products were made first in Nagasaki about 300 years ago. The tortoise shell is worked into various valuable inlaid products, toilet articles, knife handles and ornaments, such as cuff-buttons, combs, soarf-pins, ear rings, etc. Tortoise shell has been highly prized for ornamental purposes since early times. Instead of Hawksbill tortoise, green turtle is also used for tortoise shell work. The latter is less expensive than the former.

The shields are removed from the shell of the turtle either by immersion in boiling water or by heating over a hot fire. When the plates are first removed, they are keeled and curved and irregular in form. Tortoise shell can be welded when hot by pressing the pieces together in a vise.

IV. Coral Industry

Japanese coral fisheries have been worked in Kochi Prefecture, the Goto Islands in Nagasaki Prefecture, Amami-Oshima, Tokyo Prefecture, and the Bonin Islands. In Japan, coral is found chiefly in south-western waters affected by warm currents. In this country, coral is divided into 3 categories by colors pink, red, and white. The pink coral is the most profitable, the red coral follows. Coral resembles plants in form, but it is a single, complete branch bearing a great number of organisms, the polyps, which form a sort of colony. During the life of these animals the red calcareous material of the branch is covered with a thin, fleshy, reddish rind, termed the coenchyma, in which the polyps are embedded. They are distinguished by their white hue; they secrete a lime which serves to build up the structure of the branch. These branches do not seek the light as plants do, but spread horizontally along the base to which they are firmly attached. The fleshy rind covers the entire coral up to the ends of the braches, which are therefore soft and pliable and can be shaved with a sharp knife. If a living coral branch is allowed to dry in the air, the skin, or brick-red rind, hardness, and little protuberances appear, containing the polyps. These protuberances have a round aperture in the center from which eight short ridges radiate out. Coral, as it is obtained by fishermen, is called rough coral. The lower portion of the main stem and the dishlike "foot" of the coral stock are called "dead" or "rotten coral". Coral, in which a black color extends through the whole or a large part of its substance is called "black coral".

Red coral of all kinds, with the exception of pieces of exceptional size is called "common red". The term embraces alike whole stocks and broken fragments irrespective of form and size. Pieces of exceptional size or beauty selected from ordinary red coral are called "selected pieces". These pieces are very highly valued.

The specific gravity of coral, ranging from 2.6 to 2.7, closely approaches that of calcite, but its hardness, 3.75, is a little greater owing to slightly different composition. This low hardness facilitates the carver's or turner's task. Although coral does not take a fine polish, its beauty of hue compensates for that ; although not very hard, the material has toughness and tenecity and wears well. As it is slightly opaque, scratches do not show. Since it is composed chiefly of calcium and magnesium carbonates, acidulous perspiration affects its surface. Coral is damaged by heat and it is difficult to divide or dye. However, if it is desired to change red coral to a pink color, it is soaked in hydrogen peroxide solution (available oxygen 0.5 %) at 40°C for several days, renewing the solution when the available oxygen is lost. The principal use of coral is for beads to be strung as necklaces, bracelets or armbands or for other ornaments, such as tie-pins, cuff-buttons, or for mantle piece ornaments. The working technique consists of cutting, shawing, carving and polishing.

PEARL ESSENCE INDUSTRY

I. Introduction

Pearl essence produced from scales of herring, sardine or salmon for imitation pearl or other uses, was made first about 50 years ago in Japan.

Recently pearl essence has been mixed with lacquers of plastics for use in decorating many articles: mirror backes, manicure and toilet sets, jewelry boxes, umbrella handles, opera glass handles, electric light switches, etc. Because of the large demand for pearl essence, it has been imported from the United States to the extent of about 8,000 pounds per year.

Pearl essence is made from scales of fishes, especially ribbon fish ("tachi-uo") (*Trichiutus japonicus*), of which the whitish silver substance is guanine. Guanine in fish scales, which combines with collagen and calcium phosphate shows whitish silver as a result of refractive and reflex phenomena. In Japan, scales obtained from ribbon fish are mainly utilized to make pearl essence. Recently synthetic pearl essence has been made from basic lead carbonate.

II. Manufacture of Pearl Essence from Scales

Scales are removed from ribbon fish with a bamboo spatula. There are two methods to obtain "pearl essence".

1. Separation of pearl essence by gasoline

The scales are soaked in gasoline to separate pearl essence from protein and water. The pearl essence is transferred into gasoline whereupon it floats to the surface. The separated pearl essence is then filtered to obtain the fine particles of essence. The precipitate is poured again into gasoline.

2. Separation of pearl essence by protease

To fish scales is added protease, e. g., trypsin, to dissolve fragments of skin. Benzol or ether is added to the digested scales. Then pearl essence will then float to the surface. It is then separated and filtered. The yield of pearl essence according to species of fishes is shown in Table 20-1.

Table 20-1. Yield of pearl essence according to species of fishes

	Body weight	Weight of scales (g)	Weight of pearl essence from the scales (g)
Ribbon fish	per 100 g	1.4	0.288
Sardine	〃 100 g	1.9	0.100
Saury	〃 100 g	5.3	0.050
"Konoshiro" (*Konosirus punctatus*)	〃 100 g	4.5	0.036
Salmon	〃 100 g	2.0	0.012

The pearl essence is about 30 microns in length, about 3 microns in width, and its specific gravity is about 1.60. The scale essence is washed first with a dilute solvent which is used as carrying base. It is then mixed with the concentrated solvent. The mixture is stored until it is used. The pearl essence imported from the United States is made from the pearl essence mixed in concentrated celluloid solution. This is about 20～60 microns in length and 6～8 microns in width. It is desirable that the pearl essence be made from fish scales removed from fish before processing, in the interest of the full utilization of marine products.

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